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PROCEEDINGS OF FOURTH ANNUAL CONVENTION OF AMERICAN FOUNDRYMEN'S ASSOCIATION.

PITTSBURG, PA., MAY 16, 17, 18 and 19, 1899.

The first session of the convention was called to order at 10 o'clock on the morning of May 16, in the convention hall at the Monongahela House, by Mr. William Yagle, president of the Pittsburg Foundrymen's Association.

Mr. Yagle: Mr. President and Members of the American Foundrymen's Association—During the last convention of your association, held in the city of Cincinnati, you were cordially invited, through their official representatives, by the city of Pittsburg, the Pittsburg Chamber of Commerce and the Pittsburg Foundrymen's Association to hold your next meeting in the city of Pittsburg. In response to those invitations you have assembled here for the purpose of attending the meetings and taking part in the proceedings; but before you are called to order in regular business session, I take the liberty, on behalf of those who have invited you, of appropriating a portion of your time in order to have an opportunity of introducing to you a number of our prominent citizens who will address you.

I now have the honor of introducing to you the Hon. W. J. Diehl, Mayor of the city of Pittsburg.

Mayor Wm J. Diehl: Gentlemen of the American Foundrymen's Association—The highly agreeable duty devolves upon me of extending to you, in the name of the city, a welcome to Pittsburg. It is a duty which I take sincere pleasure in performing, and in doing so I can assure you that the welcome with which Pittsburg greets the representatives of the great foundry interests of our country is one of the heartiest and most cordial nature, and coupled with it is the wish and the hope that your visit to Pittsburg will prove a pleasant and most enjoyable one.

You could have chosen no more fitting place in which to hold your fourth annual convention than what is aptly and truthfully termed the "Great Workshop of the World." Many of you, no doubt, have visited us before, and know Pittsburg personally. You all know it by reputation, at least, and know of its marvelous industrial resources and achievements. But I don't propose to bore you with any eulogy of Pittsburg. The city is here to speak for itself. It is open for your inspection, and what you are able to see of her during your visit will, I am certain, interest and impress you in a far more forcible manner than any recital of her claims to distinction and greatness possibly could.

Pittsburg is old in the foundry business, for the first foundry was established within her borders away back in the early days of this closing century. It was in 1802, to be more exact, and the first stove foundry in Pittsburg followed in 1830, and ever since those early days the foundries of Pittsburg have occupied a conspicuous place in the great list of the city's manufacturing industries. We are a very busy people here in Pittsburg, but we are never so busy that we cannot spare a little time to play the host in that truly hospitable manner for which we have become somewhat noted throughout the United States. The members of the Pittsburg Foundrymen's Association, your particular hosts, have made ample preparations for your entertainment while here, and I am sure that they will conduct affairs in such a way that

nothing will be left undone by them to enhance the pleasure and comfort of your visit in every possible way.

You will be shown the great and multifarious industrial wonders of Pittsburg; its big steel and iron mills; its vast electrical and air-brake works, and, in addition, the many interesting institutions of the city and the beauties of its parks and boulevards and the fine residence portions of Pittsburg will be pointed out to you. There is much for you to see here, and the Pittsburg foundrymen have provided for every spare moment of your time.

In behalf of the city of Pittsburg, then, I take extreme pleasure in tendering you a warm and hearty welcome to this hospitable city we Pittsburgers love so well, whose capacity as an entertainer you will be given full opportunity to test, and I trust that you will carry back with you to your homes the assurance that Pittsburg was heartily glad too see you, that she wishes you to come again and often, and that she rejoices in the prosperity that has come to you as foundrymen, in common with every other line of manufacture and trade in this great country of ours, and also in the growth and prosperity of your strong, lusty and progressive three-year-old organization, and it is with great confidence that she places in your hands the key of the city with the belief that you will walk in a straight and good way. I have had removed from over the doors of the city lock-ups the word welcome, and should any of you stray off or get lost, your badge will be sufficient identification to carry you to a harbor of safety. I now place the city at your disposal.

Mr. Diehl here presented to President Bell a mammoth key in a neat case, an exact reproduction of the original key to the famous French Bastile.

Mr. Yagle: In introducing the next speaker, I wish to state that during his earlier life he was employed in a foundry and, discovering his mistake before too late, abandoned the foundry and entered the legal profession. He is now one of the most prominent members of the Allegheny County bar, and is at the head of the legal department of the city of Pittsburg. It is said of him

that during his administration as District Attorney of Allegheny County, criminals would plead guilty in preference to coming before him for trial. Only a few days ago the present District Attorney, while addressing the jury in a noted case, stated that he was the best District Attorney Allegheny County ever had. I now take pleasure in presenting to you Clarence Burleigh, Esq.

Mr. Burleigh: Mr. President and Gentlemen of the American Foundrymen's Association—I am really embarrassed by the introductory remarks of your chairman. I never could imagine why I was invited to address you, and even yet cannot decide whether it is because I am said to be somewhat of a criminal lawyer and my services may be needed by many of you before you leave the city, or whether it is because I started out in life as a pattern-maker. If I must modestly admit that I have that mechanical distinction, it must also be stated that I was quite young in those days—those good old days, when as a pattern-maker I used to have many a tilt in the foundry as to whether it was the pattern-maker's fault because the pattern refused to draw, or whether it was because of the clumsiness and haste of the molder.

Then, again, I am surprised and gratified at your preliminary proceedings. You have only been in session about fifteen minutes, and yet certain signs of conviviality already flourish in this hall and must have been observed by many of you. We have all heard the story of the old lady who said she knew her son never drank anything at night because he was always so thirsty in the morning; and when I saw the bell-boys bring in those two large pitchers of ice water and place them before your president, I realized that he must have had a very large time last night—the first night he spent in this city—and I also realized that, if you gentlemen, who are so used to handling "flasks," opened your annual proceedings in this manner, it was a bad thing to have the word "welcome" removed from over the door of the lock-ups and the jail.

But, gentlemen, what is this Pittsburg to which we bid you welcome? It is a city famous the country over, and I think I can

truthfully say, famous the world over. It is the great Iron City of the West, that stands at the portals of the great Keystone State, at the confluence of the two great rivers, the Allegheny and the Monongahela; whose soil is sacred with our country's history, and glutted with nature's richest wealth; a city whose manufactories are gigantic and legion and the never-quenched fires from whose furnaces transform night into day, and the finished products of which, wrought out of nature's raw material by the deft fingers of our artisans, reach into every country and every clime, carrying convenience and luxury to them and bringing plenty and prosperity to us—a city which refuses to recognize the impossible in anything manual or mechanical, whose tonnage surpasses the tonnage of New York harbor to-day—a city with its output almost fabulous, with its machinery almost human, and which has, by virtue of her marvelous achievements in all manufacturing lines, absolutely earned the right to be recognized throughout the globe as the greatest manufacturing metropolis of the earth.

Here, with our armies of skilled workmen, is manufactured almost everything necessary for furnishing convenience or luxury, whether for the home or the office, the mill or the farm, for this country or for the other nations of the world; and incidentally, and at the present time, let me simply remark that within the limits of this municipality are made those projectiles and that armor plate which made possible the wonderful victories of Schley and Sampson and Dewey.

To all these great enterprises of our city you are heartily welcome, the doors of them all are opened wide and your inspection not only invited but urged, and it is the hope and wish of all that you will accept these invitations, and that every moment you spend with us will not only be pleasant but profitable also, and when the few hours that you are to give to this city have passed away and you have returned to your respective homes, there will live in your memories the most pleasant recollections of this convention held by you in this "Smoky City" of ours.

Mr. Yagle: On behalf of the Chamber of Commerce of this city, I now introduce to you its president, Mr. John Bindley.

Mr. Bindley: Mr. President and Gentlemen of the American Foundrymen's Association—He who is thrice welcomed is welcome, indeed. It is a pleasure to extend greetings to so intelligent a body of gentlemen as are here gathered, representing as you do not only the practical, but also the scientific knowledge of your vocation, and coming together for the disseminating of this information, to the end that there may be an uplifting and advancement of your business. It is fitting and proper that Pittsburg should be selected as the place of your convention, as this is the center of the metal industry, and we hope that your stay with us will be not only educational, but also profitable, as well as one of unalloyed pleasure.

By request I am to occupy a few minutes of your time, dwelling upon the commercial importance of Pittsburg, a theme which never grows old. Owing to its ever-changing and advancing conditions, Pittsburg from its earliest days has been, not only an historic spot, but also an important commercial one. In 1758 Gen. Forbes, with his army, representing the English government and her colonies, crossed the mountains and wrested from the French and their Indian allies Fort Duquesne, which was located within a gunshot of where we are now holding this convention. This victory practically settled the question as to whether the Anglo-Saxon or Latin would dominate this hemisphere. The settlement was called Pittsburg, after the great English commoner, and became the gateway of the west. Here were gathered the stores and essentials necessary for the subduing of the great primitive forests, thence transported by means of the natural water ways to their final destination. Thus in its infancy this became an important place, continuously growing in importance, in its early days not so rapidly as some other points, but with a solidity which gave it a foundation that is now able to carry any and every structure that may be placed upon it. The growth within the last fifteen years has been phenomenal, and great as this growth has been, it will be surpassed by the present rapid advancements, our development and growth being beyond the fondest anticipations of the most ardent Pittsburger.

Pittsburg is much greater, commercially, than the statistics of the enumeration of her inhabitants would indicate. The census of 1890 placed within her municipal border 239,000 people, but unfortunately for our statistical record, our border lines are very much circumscribed, for instance, Allegheny county (of which Pittsburg is the capital) contains practically five cities, which are in fact as much integral parts of our city as those located within its boundary lines, and owing to a sentiment, which seems false, these conditions will not be changed prior to the taking of the 1900 census, and we may retain the present thirteenth place in list of cities, instead of attaining our proper position—the fourth city in the Union. According to the census of 1890, taking a circumference of 60 miles, with Pittsburg as the center, we had a larger population than any city west of the Allegheny mountains; within the same prescribed limits, astounding as it may appear, we had almost 100,000 more than Chicago, 500,000 more than Cincinnati and 700,000 more than St. Louis. This will partially explain and account for our financial and commercial position in the business world. Located in the center of almost inexhaustible beds of the finest bituminous coal, settled by a people, with a blending that makes them progressive, aggressive and unyielding in their determination, with an irresistible activity that has developed and created this wonderful and unique city into the capital of the greatest manufacturing empire in the world. The shipping facilities are carefully guarded with jealous eye, as Pittsburgers fully recognize the value of the economies of cheap transportation, and it is ever the aim of those who foster the interest of our city to constantly demand better, greater and ever improving facilities.

To-day the world's supremacy in the metallurgical art is conceded to us. It has been wrested from Great Britain. The world is our market, and we stand almost without a rival, as our products are sent to every part of the civilized globe, and our name and fame will everywhere become as familiar as household words.

Our city is unique in its creation of wealth. Here the raw material is taken, and by the various processes developed until finally

its value has been greatly multiplied, whereas in many manufacturing localities the cost of raw material is a very large per cent of the article produced. Financially, we have a banking capital (including surplus) of $40,000,000; deposits about $140,000,000. In the clearing house exchanges we, to-day, are the fifth city in the Union, being exceeded only by New York, Boston, Chicago, and Philadelphia. As manufacturers and producers we are pre-eminent in the following, outranking in production any city in the world: Steel and iron, plate glass, table glassware, window glass, tin plate, steel and wrought iron pipe, coal and coke, air brakes, electrical machinery, pickles and condiments, oil and gas. Our annual product of pig iron is over 3,000,000 gross tons, or 27 per cent. of the total production of the United States. Our production of bessemer steel is over 2,000,000 tons, or 37 per cent. of the whole. Of open hearth steel, our output is 1,500,000 tons, or 65 per cent. of the whole. The total production of bessemer and open hearth steel for the United States for the year 1898 was 8,829,500 tons, of which Pittsburg produced 3,500,000 tons, or 40 per cent. of the whole. Of crucible steel we produced 60 per cent. of the whole; structural steel, 63 per cent.; plates and sheet, 33 per cent.; wire and nails, 30 per cent. In the steel pipe and tube industry, we lead the universe. Of coke we produce 8,500,000 tons, and our Connellsville coke is famous beyond comparison. Of coal, our production in round numbers was 17,000,000 tons.

Glass—The Pittsburg district produces of table glassware 63,000 tons annually; window glass, 40 per cent. of the total production of the United States; plate glass, 75 per cent. of the whole; tumblers, one firm has capacity to produce 5,000,000 dozen annually. In all these branches we have the greatest plants in existence, colossal in extent.

Oil and natural gas have been the source of great wealth to our community. The product of oil, of which Pittsburg is the territorial and operating center, produced last year over 35,000,000 barrels. The estimated daily consumption of natural gas in the United States is 200,000,000 feet, and Allegheny county con-

sumes many times more than any other county or locality. This will give you some idea of the value of these products.

The name of Westinghouse in connection with the air brakes and electrical appliances is indissolubly associated with Pittsburg, and has added fame to our name the world over. Thus far I have only spoken of the tremendously great products of this locality, but in other lines of manufacture we are large in comparison with other cities. The goods produced here are varied, and of great variety and extent. It would require volumes to tell their interesting story. We produce largely: Locomotives, lamp chimneys, aluminum, bottles, cigars, corks, whisky and have immense baking establishments. We also have the greatest of steel car works, with a capacity of 35 cars per day, and other industrial establishments too numerous to mention. In every line our mercantile establishments are in keeping with this progressive age, and fully representative of our city, comparing favorably with those to be found elsewhere.

Our press and newspapers compare favorably with any in the land, being ever alive to the advancement of the interests of this community.

In tonnage we are the greatest creators of any city in the world. We have no peers. In 1898 our tonnage amounted to 50,000,000 tons, and this year promises to reach the enormous total of 60,000,000 tons. Our car service was 2,000,000 cars, of 20 tons capacity each, placing us beyond all rivals. To this must be added our river tonnage.

Gentlemen, the foregoing figures may seem like a fairy tale, yet are as statistically true as they are wonderful. It is said that the tonnage of one of our immense establishments is greater than the whole combined tonnage of the Grand Trunk railway of Canada, and much greater than the entire cotton crop of the south. Comparisons of this kind will leave their impressions of the vastness and extent of the business and commercial greatness of Pittsburg.

Mr. Yagle: On behalf of the Pittsburg Foundrymen's Association, I greet each and every one of you and bid you welcome

and, while in the city of Pittsburg, you are expected to become our guests. Entertainment has been provided for you and your ladies, in which you are all most cordially invited to participate.

The visiting ladies will be taken care of by the "Ladies Committee," and will not want for anything during the meeting of the American Foundrymen's Association in this city.

With the thanks of the Pittsburg foundrymen for your large attendance and kind attention and the hope that your meetings will be successful, I now turn the convention over to the proper authorities and introduce to you Mr. C. S. Bell, President of the American Foundrymen's Association.

Mr. Bell: "In behalf of the American Foundrymen's Association I take great pleasure in thanking you for the cordial greeting you have extended to us. We appreciate your welcome and our visit to your city is made doubly pleasant by the kind words and hearty greeting that we have been favored with. We assure you that we shall ever cherish a pleasant recollection of this very cordial reception.

The American foundrymen are meeting in their annual convention for the purpose of renewing friendships formed at previous conventions and enjoying the fellowship of kindred interests. We believe in fostering kind feelings among men in similar industries, rather than those antagonistic conditions that have prevailed in the past. We wish to know the better side of our competitors and appreciate good fellowship with all.

Our meetings are open to all, and we have invited all foundrymen and those of allied interests to meet with us and assist in such an exchange of thoughts as will be both a pleasure and a benefit to the entire foundry interest of America.

The local committees having in charge the arrangements for this convention have made such an attractive program that we cannot but enjoy every hour of our stay in your city, and I but echo the sentiments of every visitor in extending the thanks of the Association to the committee who have provided so elegantly for our entertainment.

The provision to entertain the lady visitors deserves special mention, and we make our acknowledgments to the committee for this innovation, but especially do we bow our acknowledgments to the ladies who grace our convention by their presence.

The conditions that surround the foundries to-day are somewhat peculiar. While they have partaken of the general prosperity of the country to the extent of increased business, they have not enjoyed the advance in prices that the producers of the raw material have secured and in many instances this results in great hardships and in some cases actual loss. Contracts made in the early months of year based on prices of pig iron at that time would not yield a profit if the iron had to be purchased now.

These conditions will adjust themselves after a while, provided the price of iron should maintain its present position. If, however, there should be even a slight decline, it would be very difficult for the foundryman ever to recoup his losses.

The foundrymen, with all other citizens, of this country, appreciate the exalted position we have achieved during the last year by the valor of our army and navy. While we all believed that the results of the contest would be in our favor, yet few ever dreamed of such results as were secured by our representatives in the field and on the sea. And I believe it will not be trespassing on the field of party wisdom to express our appreciation of the ability and wisdom of the president of the United States, who has so successfully brought to an end the war with Spain and with such glorious results."

Mr. Bell: We will now listen to the report of our Secretary.

SECRETARY'S REPORT.

Mr. President and Gentlemen of the American Foundrymen's Association: Just what is appropriate and what is not in any report that might or ought to be presented at a gathering like this is a question that has recurred before this to your Secretary. As our constitution is silent upon this point, it has hitherto been largely a matter of either inspiration or judgment.

In previous reports extended reference has been made to the value of membership in an Association such as ours aims to be and many reasons have been cited why such membership ought to be valuable.

The work that has been done and fostered by the Foundrymen's Associations of America and this one in particular, the amount of information that has been prepared and submitted and published are all matters of record.

The acquaintances and personal friendships that have been made among those formerly strangers and the value, pleasure and profit of those acquaintances, no one can ever estimate, though we all feel that they form a great part of our lives: assets, alike precious to each and worth to the man especially who likes to meet his fellow men and can realize the benefit of the interchange of ideas, views or plans more than he might realize or be willing to admit.

It would seem to be rather remarkable but true nevertheless that those individuals or concerns who are the most willing ordinarily to assist movements designed perhaps to benefit in a general way all those who may be affiliated with it, are the ones who in their turn are the most successful themselves, which would seem to be an argument that a broad-minded and liberal policy is equally as valuable in business as elsewhere.

As an instance of what may be done through or by an Association of this character, or as a result perhaps of its stimulating influence or the indirect support given, your Secretary would like to briefly draw attention to the work of one committee especially appointed at our last meeting, and who are to submit a report at this one.

The committee referred to is one appointed to investigate and report on the Standardizing of the Testing of Cast Iron, and of which Dr. R. G. G. Moldenke, of Pittsburg, is chairman. While a reference of this character in a report of this kind may not be usual and while your Secretary has not in any way had anything to do with the work of this committee, yet in view of the great importance of the work undertaken, the immense amount of

labor involved in investigating and arriving at the results, this committee is in a position to present through this Association to the foundry and iron interests of the entire world, a report superior by far to anything ever previously attempted, and it may not be out of place to refer to it here as an evidence of the work the Association is doing.

For many years during the recent severe business depression no one suffered from all the evils manifest in that most trying time, more than the foundry operators of the country, and as a result of this, foundry proprietors have shown naturally a great aversion to doing anything towards improving facilities or in any way increasing their investment.

With the advent of the great change, however, that has taken place in the business situation during the past few months, a large number of deferred plans for improvement have been put into operation and as a result more is perhaps being done in this line just now than at any previous time.

Another matter worthy of passing remark is that it is being done more intelligently and not so much with an eye to immediate economy as for the purpose of future permanent benefit.

While in all Associations of the purely voluntary character of this one there is sure to be more or less fluctuation in the membership, for one reason or another, yet it is gratifying to know that the addition of new members in our case, has kept our number slightly above the three hundred mark, and this too without as aggressive a campaign for increase in this direction as might perhaps have been possible.

At our Detroit meeting in 1897 a committee, that with Mr. W. H. Pfahler as Chairman, had been busily at work for some time, presented a report recommending that this Association should lend all the assistance in its power to the formation of an Association for the purpose of equitably and yet finally putting an end to all labor troubles of its members, similar to those methods that had been so successful among the stove founders of the country.

Growing out of this report and the preliminary work done by this Association, the National Founders' Association was organized over a year ago and the American Foundrymen's Association has much to be proud of in contemplating its splendid growth, and the good work now being done by it.

It has been said more than once that if our society had never done anything else than just this one thing the foundry trade of America would owe it a debt of gratitude it could never repay.

Our receipts and expenses since our last convention have been as follows:

Balance on hand June 6, 1898	$ 414 79
Dues received	2,070 00
Total	$2,484 79

DISBURSEMENTS.

Journal	$ 808 84
Salary	1,171 00
Expense, incidentals or miscellaneous	83 15
Printing	65 75
Postage	94 19
Cash on hand	261 86
Total	$2,484 79

In conclusion your Secretary would like to express his sincere appreciation of the great courtesy of those who have so kindly volunteered to prepare and read papers at this meeting, of the work done by the members of the Pittsburg Association and the foundrymen of this vicinity to make this meeting successful from every standpoint.

JOHN A. PENTON,
Secretary.

Moved and seconded that the report be accepted.

Motion carried.

The Secretary here explained that owing to the recent severe illness of the Treasurer, Mr. Howard Evans, he was unable to be present at the convention.

It was moved and seconded that a committee be appointed to wire Mr. Evans the congratulations of the convention upon his improved health, and the wish for his speedy and complete recovery.

Motion carried.

Chair appointed Mr. J. S. Sterling, Harlan & Hollingsworth Co., Wilmington, Del.; Mr. W. A. Jones, W. A. Jones Fdy. & Machine Co., Chicago, and Mr. F. H. Zimmers, Union Foundry & Machine Co., Pittsburg, to act on this committee.

The Committee on Standard Specifications for Testing Cast Iron then made the following report:

REPORT OF THE COMMITTEE ON STANDARDIZING THE TESTING OF CAST IRON.

COMMITTEE'S PROGRESS REPORT.

Gentlemen:—Your committee herewith presents a report of the progress made during the past year on standardizing the testing of cast iron. It was the hope of the individual members to have some conclusions to present for action at this convention, but the phenomenal activity of the trade made it impossible to get out any more than one-third of the work in contemplation. Nevertheless, the subject has been studied carefully and definite plans laid out which, if not delayed too much, should conclude the labors of your committee in time for a final report at the next convention.

It is our policy to publish results as fast as they are available, in order to make the data thus obtained serve the general trade in many ways, allow anyone who wishes to do so to make his own calculations and deductions therefrom, show the constructor something of the real nature of his material, and invite other workers in this field to aid us with comment and criticism. We hope, moreover, to have emphasized the necessity of more light shed upon cast iron, in this way helping the work of our sister organizations already in the field, and thus the combined action of all investigators cannot fail to be in the highest measure valuable to the iron industry of the world.

Your committee in pursuing this course of publicity presents in this report an outline of the scope of the work as originally laid out and in course of completion, adding a few remarks on the motives underlying the selection of the lines of operation adopted, and some generalization on the subject of the possible ultimate methods of testing the foundry product to satisfy consumers.

At the outset a study of existing results was undertaken, and here we were confronted with the fact that since the time when the well known government tests were made, upon which its present specifications are still based, many changes in our views and additions to our knowledge of cast iron have taken place. The effect of chemical composition combined with physical structure is now better understood, and so we were reluctantly compelled to outline a much larger plan of operations than had been at first thought necessary. The results will, however, doubtless help us to a better understanding of what has been done and fill many gaps now painfully evident.

To standardize the testing of cast iron it is first of all necessary to know how it behaves under conditions which can be readily duplicated in any foundry at any time. This brings us at once to the question of what cast iron is, and takes into consideration the chemical side of the problem. With iron containing a minimum to a maximum of silicon, manganese, phosphorus, sulphur and carbons, in proportions almost defying classification, one standard test bar will exhibit all kinds of probable and improbable properties, giving little to go on except for the particular combination for which it happens to be suitable. We therefore concluded that whatever series of tests were made they would have to be repeated systematically to a greater or less extent upon the various commercial grades of castings. The 12 selected are as follows: Ingot mold iron, dynamo frame iron, light machinery iron, heavy machinery iron, cylinder iron, stove plate, gun metal, chilled roll, sand roll, car wheel, novelty iron, and sash weights. Of these there are full sets of tests and only partial ones the work being too large to go into refinements.

with some classes of iron which from their very nature cannot be used in but one or two ways.

We can report the completion of the first three sets of tests and the fact that two more are under way at the present time. A number of additional studies are contemplated, of which the first, on the transverse test, has been completed, and several more are under way. The magnitude of the work will be better understood when it is stated that so far there have been cast 667 test bars, which furnished 943 test pieces, 456 of which were machined, the total number of tests made being 1,015, and the aggregate weight of the material handled having been 12,270 lbs. All the available scrap was returned to the very liberal donors in order to reduce their outlay to the greatest extent possible.

The patterns and flasks were donated by The McConway & Torley Co., Mr. Thos. D. West, and the chairman of your committee, who also looked after the machining of the bars, the preparation of the fractures for exhibition and the work of testing, being ably assisted by Mr. A. Pechstein and the rest of his force in these labors.

The next question which arose was, "Given the various kinds of irons, to what tests shall they be subjected to get tangible results as a basis for our study?" This was settled as follows:

(1) The tensile test up to the limits of the testing machine and its clamping devices; that is, up to 4 sq. in. sections.

(2) The transverse test also up to the limits of the testing machine; that is, with 12″ supports, the cross section to be up to 16 sq. in.

(3) The compression test on ½″ cubes, thus allowing the smallest bars to be compared with similar portions of the larger ones.

(4) A chemical analysis of the 1″ square dry sand bar to get an idea of the material dealt with. It is well understood that the effects of segregation (which includes the formation of graphite) will give an interesting series of chemical studies when applied to the range of test bars contemplated. These effects, however, are the direct result of the casting temperature and the rate of

cooling due to size of bar and composition of metal, and while important in their bearing upon the strength of the bars under test, are rather of a scientific interest, and hence left for future investigation.

(5) It is regretted that no machinery is available for reliable impact tests, your committee deeming this method of testing a most important one, the only one in fact giving a true insight into the resistance of cast iron to shock. The future will doubtless bring this test forward more prominently, but whether in time for our work or not cannot yet be said. A test for hardness might also be a desirable one, and several excellent methods have been brought forward. It will be applied locally, however, each shop selecting the method best adapted to test its work. The hardness test was therefore omitted from our list with some reluctance. A mere glance at the fractures of the bars tested will show that from the central portion outward the hardness is a regularly increasing quantity which reaches its maximum in the skin of the casting. A range of tests for hardness from center to edge might therefore be very interesting scientifically, but will hardly be essential in the drawing up of specifications. The same holds true for the shearing, punching, and hammer test for cast iron.

(6) A test for fluidity in the shape of a very long narrow wedge, one face of it to be against a chill, the observation to be the manner of filling this out.

(7) A test for chilling quality on the part of the metal, the fracture of the test blocks to be photographed for record.

(8) A test for contraction. This is to be made by means of small depressions in the mold exactly 12 inches apart, a suitable instrument being provided for the purpose.

(9) Finally, if time and facilities permit, some investigations are to be made on the cooling curves of these irons, using a mirror reflection of the movements and bromide paper with the recording apparatus. The microscope, it is hoped, may also reveal something of the ultimate structure of the irons thus studied.

In addition to the above rather comprehensive programme,

a few extra studies have become necessary in order to get some information on the testing methods themselves. Thus a series of tensile tests will be made on a number of bars varying only in their length and cast under exactly the same conditions, in order to supplement the regular results so far obtained. For this work we are indebted to the courtesy of the Pennsylvania Railroad Co., Mr. Casanave having kindly authorized the various departments interested to co-operate with your committee in the interest of the trade.

Next comes a study of the transverse test, a number of casts of bars of uniform shape and dimensions being tested with their supports a variable distance apart. These castings were kindly donated by the Frank-Kneeland Machine Co., and the tests are completed and tabulated.

The European method of making test bars comes in for some study. Mr. West has made a set of bars which will be split longitudinally to obtain comparative figures from the upper and lower portions, this work, by the way, being nearly complete, and another series of these European tests, as well as a set of tests on cylinder coupons, are on the programme of our P. R. R. friends.

In arranging for the regular series of tests the following comparisons were kept in view:

(a) Differences due to the shape of the cross section of the bars; that is, round and square test bars compared. For each size, therefore, the areas were made equal as the tables already published will show.

(b) Differences due to the dimensions of the cross sections of the bars. Thus the square bars ran $\frac{1}{2}''$, $1''$, $1\frac{1}{2}''$, $2''$, $2\frac{1}{2}''$, $3''$, $3\frac{1}{2}''$ and $4''$, and the round bars were equal in number.

(c) Differences due to the condition of the test bars. That is, whether rough or machined. In this line of work the machining was made rather heavier than is usual for testing purposes, and hence the delicacy of the test is somewhat impaired. Still in practice machined castings usually have much more than the mere skin taken off, hence a true comparison of machined work

with rough is better exemplified in our test where $\frac{1}{4}''$ was taken off all around from the square bars and a corresponding amount from the round ones. In this way the rough bars were cut down to the next size below, and thus a 2″ rough bar can be compared with a 2″ machined one, the latter being originally a $2\frac{1}{2}''$ rough bar.

(d) Differences due to molds; that is, green sand castings and dry sand.

The success or failure of the whole work will naturally depend upon whether the results are comparable or not, and the getting up of specifications to accomplish this gave us much concern. The final outcome of a number of plans was drawn up upon the following basis:

In a full set of bars, half are to be cast in green sand and half in dry sand, or cores as the facilities of the donors allow it. Again, of all these bars half are to be tested rough and half after machining. The transverse bars to embrace all the sizes made, and the tensile to run no heavier than the 2″ square and round bar of equal cross section. Since the tensile bars are of a different shape than the transverse, and the lowest number of tests for a comparison must be two, each separate pattern had to furnish eight castings; that is, four in dry sand and four in green, of which two each were machined. With 24 patterns this meant 192 bars, not counting the chill pieces and fluidity strips, and as it was decided that these bars must be cast at one time and in a vertical position to get comparable results, the outcome was somewhat problematical. To our Mr. West was allotted the task of planning the molding and casting the first set. This he did with complete success, and the thanks of the foundry trade are due him for his disinterested work. We have next to record the generosity of the Westinghouse Electric & Manufacturing Co., who with commendable promptness gave us two complete sets of bars, the work being carried out by their Messrs. McDonald and Fuller. The remaining sets of bars, some of which are only partial ones, have all been promised, and we hope that the very desirable activity at present the rule in all our foundries may not retard the getting out of this work.

In connection with our work there is to be recorded the formation of an "American Section" of the International Society for testing materials. The American end of the great work mapped out has been entered with every promise of incalculable benefits to our growing export trade. Our association is now officially a member, and has a good individual representation besides, one of the elective offices falling to a member of your committee. The recommendation to make the study of testing methods for cast iron à separate one in the international programme was adopted unanimously, and doubtless more of this will be heard in Paris next year.

The results of our investigations are hardly in shape for an extended discussion at this juncture, and hence there remain only a few concluding remarks.

That consumers of castings propose to test the work they get is a fact patent to all who are in touch with the great interests in the trade. What shape this inspection will take is closely watched by the producer, who is naturally not very anxious to assist the average consumer in this matter. In some branches of the trade the consumer knows practically nothing of the nature of the material he buys, and it may be added that some producers know very little more. In other directions this is altogether different, and the producer is burdened with a lot of specifications which he knows amount to very little in giving what is really wanted. The founder does not as a rule object to the presence of an inspector, nor to rigid rules which he must follow, for he can make his price sufficiently high to cover this form of annoyance, or refuse to bid on the job. But the founder does object to be told that he must do so and so, and then be held responsible if the results fail to come up to the expectations of those who drew up the specifications. So that after all the problem will be taken up by two classes: on the one hand by those who insist on specifying for every casting and having an inspector to call for all sorts of things possible and impossible, and who will have to pay for the same; and on the other hand by the general run of buyers who are more likely to

adopt an impartial system of inspection once it is presented. Thus the government will always specify how its mortars are to be cast and have an inspector on the place. It has time enough, and pays for what it asks. The general trade, however, acts differently. Here dollars and cents and time count heavily; only with very heavy orders will it pay to send an inspector, for the great bulk of our orders are the smaller ones often repeated. Taking one of a hundred castings, and breaking it, gives only an idea as to what that particular casting is, for in a carload of castings of the same kind there may be included the work of a number of molders and a dozen heats. So that after all it will come to the test bar; the larger foundries having their laboratories and test rooms will be able to open their books for the inspection of authorized persons, possibly sending along additional test bars with their shipments, and afford facilities to their customers to see that their iron is good and their castings get a fair show. The smaller foundries will simply furnish test bars upon request and the buyers will test and analyze them themselves. There will be recognized standards for the composition required in the various classes of castings, and similarly standards for their strength.

To select, then, the form of test bar and method of test best suited for each case is the work which your committee hopes to accomplish after the results of all the comparative tests now making have been exhaustively studied.

We herewith present our report of progress with the hope that the work already accomplished may bring us the further hearty support of our fellow-members of the American Foundrymen's Association as well as that of the trade at large both here and abroad.

Respectfully submitted,

THOS. D. WEST,
JAS. S. STIRLING,
JOS. S. SEAMAN,
JOS. S. McDONALD,
RICHARD MOLDENKE, Chairman.

APPENDIX A.

METHOD OF CASTING TESTING BARS FOR THE A. F. A. TESTING COMMITTEE.

(From a paper read before the Pittsburg Foundrymen's Association, November 28th, 1898, by Thomas D. West.)

There is no metal whose physical qualities are so easily and radically affected by the thickness and rate of cooling as cast iron. A casting half inch thick and another four inches thick may cause the light body to be very dense and hard, while the

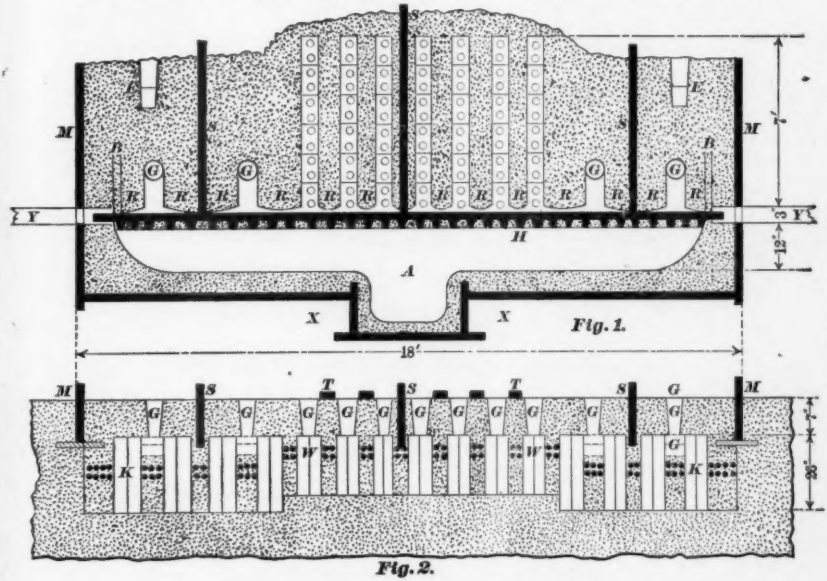


Fig. 1.

Fig. 2.

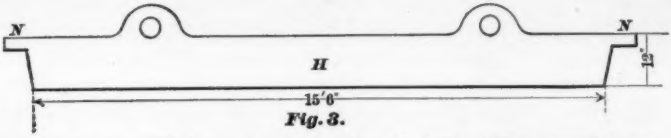


Fig. 3.

heavier body will be open grained and soft. Then, again, we can take the same thickness in two castings and by cooling one more quickly than the other, cause one to be white, while the other will be gray in its body, all being poured from the same ladle of metal.

The rate of cooling is a factor as important in its effects in altering the structure or grain of cast iron as that of differences in the thickness of casting, and can be controlled in three ways: First, by having the mold of sand or of iron. Second, by varying the nature and dampness of the sand, or thickness of the iron chill forming the mold. Third, by variations in the temperature or fluidity of the melted metal at the moment it is poured.

Fig. 4.

Variations in the pouring temperatures of metal often greatly affect the strength of iron, but in what direction, according to the grades used, is yet to be clearly established, as in some mixtures a dull iron increases the strength, while in others the reverse is true.

A study of the various conditions affecting the grain of cast iron should demonstrate that any attempt to obtain comparative

test specimens from which correct deductions can be expected, to define the physical qualities of cast iron, should be made on a plan which permits pouring at the same temperature, and casting in a position permitting the most uniform cooling and giving the most uniform grain in the specimens. These are conditions which the writer, in previous papers, has shown to be essential in making any sets of test specimens to be used for comparative purposes.

In recognition of the great need of a more correct basis for comparing physical tests, the American Foundrymen's Association appointed a committee, at the last annual meeting, to take up the work of testing cast iron with a view of assisting in the establishment of an international standard code for the foundry branch of the iron industry. To do this properly it is

necessary to obtain test bars from more than one grade of iron. It is an error to think that one grade will establish comparative records that would show what cast iron is. Instead of there being but one grade of iron to be tested, we have fully eleven grades which must be gone through before complete records of any value can be had to represent the physical qualities of cast iron. When it is stated that there are about 200 bars in many

of these grades of iron, ranging from ½ in. to 4 in. square and round, 15 in. long, half to be made in green sand and half in dry sand molds, the weight being nearly two tons for a complete set, the magnitude of the work which is being done by the American Foundrymen's Association committee on standardizing the testing of cast iron will be recognized.

In starting this work, much time was expended in completing plans of procedure as the magnitude of the undertaking required that every step be well studied to make sure of giving

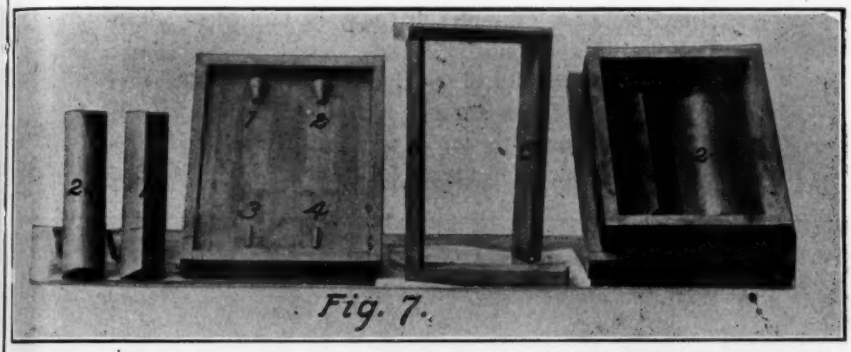


Fig. 7.

the best that was possible to obtain the true strength, contraction and chilling qualities of cast iron, as it is used to-day. After all plans were arranged, the work of constructing the patterns, core

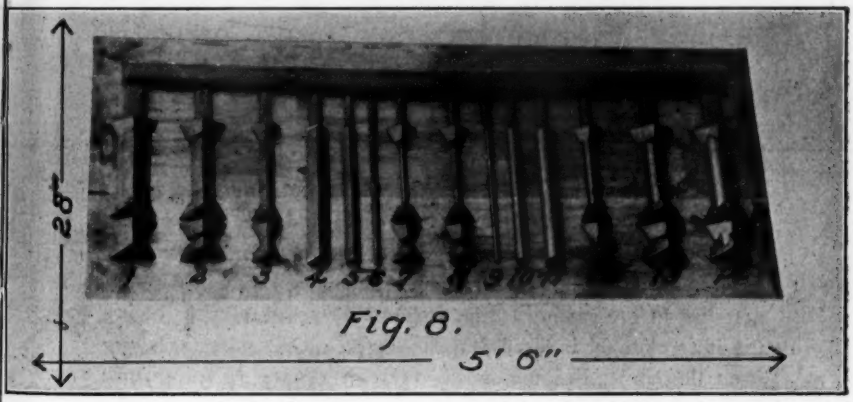


Fig. 8.

boxes and flasks were taken in hand and furnished by Dr. Moldenke and myself. Designing the method for casting these bars, and making the first set was assigned to the writer. Knowing

the importance of casting on end and pouring all bars in any set (to be used for comparative purposes) from the same ladle of iron, and if possible, at the same time and temperature, the writer originated the plan shown herewith, which has proved most successful and embodies principles that may be utilized to advantage in other lines of founding.

To give a general idea of the character of this work, before proceeding to details, the reader is referred to the illustrations. Fig. 1 is a plain view of the molds with their runners and gates, before being weighted down ready for casting. Fig. 2 is a sec-

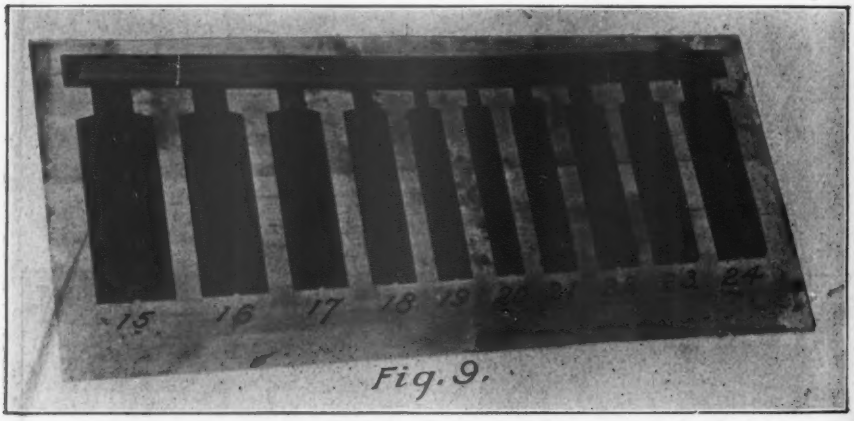


Fig. 9.

tion behind the inlet plate H. Fig. 3 is a working sketch of the inlet plate H. Fig. 4 a plan of the cores and green sand mold as they appear in the pit before the last ramming around the bodies was done. Fig. 5 is a view of all the molds and their runners just before casting. Fig. 6 shows the act of pouring, before the inlet plate H is lifted, but by reason of the gases escaping from the cinder bed under the reservoir runner A, the picture is not as clear as it might have been. Fig. 7 is a view of the core boxes; the one on the right shows the box together, the one on the left, when it was taken apart. Fig. 8 is a face view of a mold board, showing the arrangements of pattern and gates;

the same is to be said of Fig. 9. Fig. 10 shows a flask closed and on end ready for pitting. Fig. 11 gives two views of the tool used for printing tits in the molds to measure the contraction. Fig. 12 is an end and side view of cores used in molding the tensile test bars. Fig. 13 is an end and side view of the pattern used at G to form runners over all the cores as at W (Fig. 2). Fig. 14 shows the form and plan of casting to obtain knowledge of the chilling qualities of the various grades, and which is told by breaking the castings through their centers on a testing machine. The castings, as seen, are made in a wedge

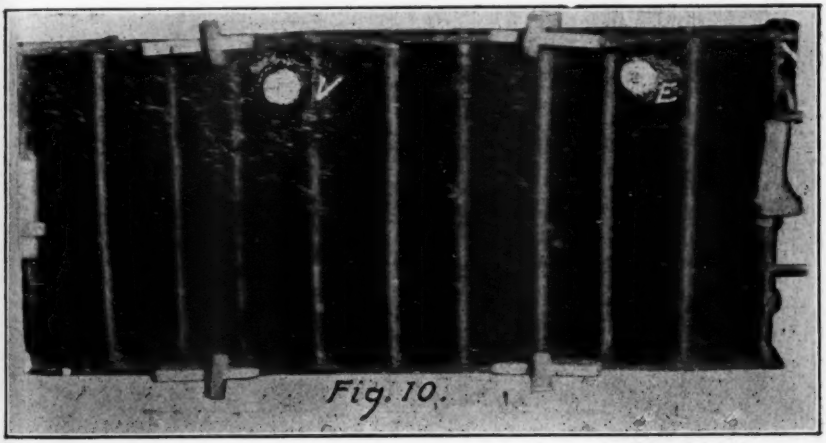


Fig. 10.

form running from a sharp edge to 4½ inches thick. This permits the one form and size of a casting to be used throughout all grades, a plan essential to obtain a comparative knowledge of the difference in the chilling qualities of the various mixtures which will be tested. These chill tests are made in a core as seen at D, Figs. 4 and 14. The faces of these cores are covered with part chill and part core, as seen at E′ and H′, Fig. 14. The chill E′ is 1½ inches thick.

A fluidity strip ⅛ inch thick at the base running up to a knife edge 14 inches long, as seen at X′, is gated in connection

with the large casting K′ as at R′, Figs. 14 and 15, so that they can fill up only as fast as the chill castings do, which prevents any sudden dash of metal from giving a false effect in recording the fluidity of the metal. The length of these strips will give a fair idea of the difference which may exist in the fluidity of the

different shops' metal, or if any dull iron was used at the moment a set of bars is poured. These fluidity strips will also serve to assist in defining the chilling qualities of iron in combination with the large casting K′, as it is to be remembered that the hotter or more fluid metal is poured, the deeper it will chill, another evil or irregularity due to non-uniformity in pour-

Fig. 12.

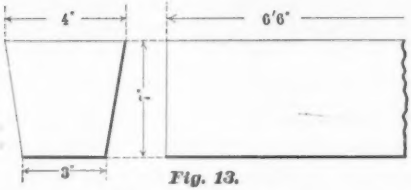


Fig. 13.

ing temperatures, which the writer has proved by previous experiments.

Fig. 15 affords a view of the first cast of test bars and chill tests, as they were taken from their molds and cleaned ready for shipment to the testing laboratory. Those on the left with flat gates were made in green sand, while those on the right with

round gates were made in cores. Preparing for and making this first set of test bars involved about 30 days' labor.

Figs. 16 and 17 give views of the second casting of test bars, which were made by the Westinghouse Electric & Mfg. Co., Allegheny, Pa. Fig. 16 shows the mold ready for casting. Fig. 16 will show that the exact plan used by the writer in casting the first set of test bars is followed, and that he did not originate a plan impractical of duplication. Fig. 17 is of value in showing the action of pouring after the inlet plate H, as described at Figs. 2 and 6, has been raised, to let the metal flow

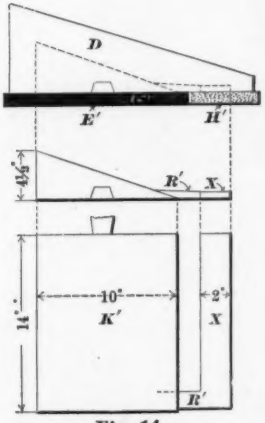


Fig. 14.

instantaneously to the molds, as Fig. 6 is only a view of the action of pouring before the inlet plate H is raised to admit the metal from the basin A to the respective molds. It is but just to remark that it requires experience in founding and men of ability to successfully oversee and mold up such a set of test bars after the plan herein described, but judging from the character of the men and firms who have consented to do this work, all may rest assured that the end sought will be as nearly attained as is possible with our present knowledge.

The flasks used for this work were all made of malleable iron so as to make them strong and light for handling. The

cross bars were arranged in the flasks so as not to come over the part of the test bars which should fracture when tested, after the plan seen in Fig. 10, which is a flask taken from the mold board, Fig 8. In mixing the facing sand for these molds, half new and half old sand, with 1 to 20 of sea coal, was used for board, Fig. 8. For the heavier patterns, seen on board, Fig. 9, the facing sand was mixed with 1 to 12 of sea coal. To form the recesses of separation of the long and short tensile test bars, as at P., Fig. 8, cores as at Fig. 12 were used, by placing them

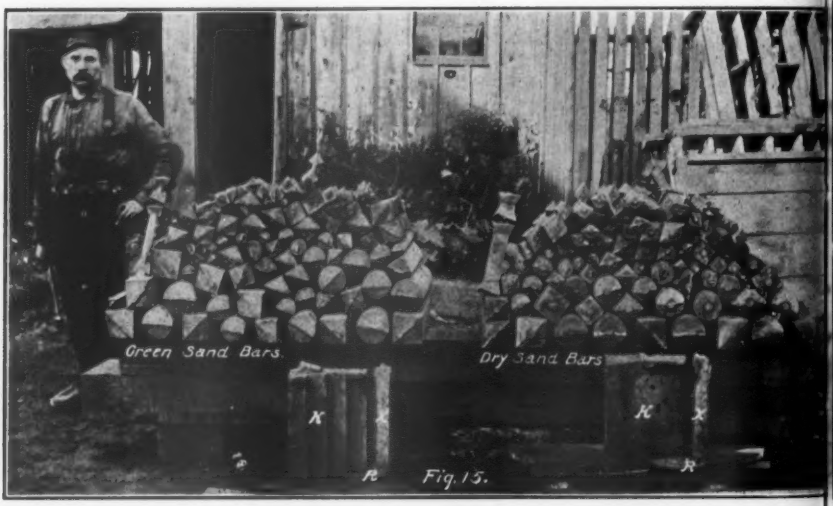


Fig. 15.

in the pattern and ramming them up with the mold. This is a little wrinkle that can often be used to good advantage in cases where green sand bodies are thought to be too small to stand the drop or wash of metal. These bars are used to obtain the tensile strength, while the straight ones seen on both boards are for transverse tests. In ramming up the flasks, a gate and riser was set on the main runner at L to look as at V and E, Fig. 10. It will be noticed that the runners L slope from the middle up to each end. The idea of this is to cause the first dash of metal

to go direct to the smaller bars to assist in assuring their running, as in chill or hard grades of metal there is often difficulty in running light bodies. In ramming the sand in the flasks, care was exercised to ram it evenly and firmly, so that no swelling or scabbing can take place. Much care is also taken in venting as well as in finishing the mold. The swab was only allowed to be used at the junction of the gate and pattern at I, seen in Figs. 8

Fig. 16

and 9. The reason for this is that if one part of the face of a mold is of a damper sand than another, it will cause an uneven texture in the grain of the iron, and hence every precaution was taken not to use the swab anywhere near that portion of the bar, which will break when tested.

As not every shop in which these sets of bars will be made is provided with facilities for dry sand work; the plan of using cores was elaborated and carried out in this first cast. Other sets among the eleven projected will doubtless have the advantage

of dry sand molds, which means a great reduction in labor and time, though the results in either case will be identical. In making a sand mixture for the cores, it was very desirable to have it of a character to crush easily when the bars commence to contract. After some experimenting the following mixture was adopted for making the cores:

1 part lake, river or bank sand.
3 parts of fine white silica or crushed sand.
1 part of rosin to 25 parts of sand.
1 part of flour to 25 parts of sand.
1 part glutrose to 30 parts of sand.
Wet balance with water.

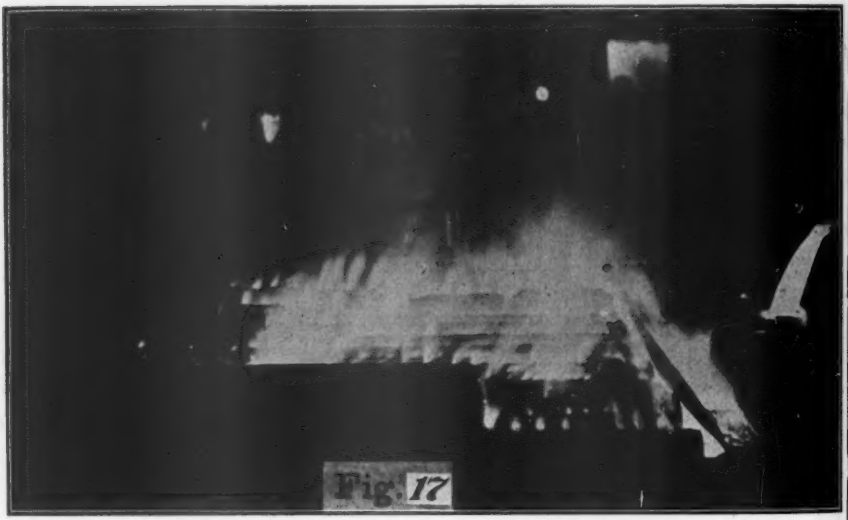


Fig. 17

This sand mixture is one that possesses very little body to stand up in a green state; so much so, that in making the larger cores rodding is very necessary in order to keep the cores together. When this mixture is dry, the cores are exceptionally strong to handle; much more so than any made with a more

loamy sand, having flour only for a bond. The effect of the above mixture when heated with molten iron is such that after solidification the core softens to such a degree as to cause practically no resistance to contraction taking place. Such a core mixture could be found of much value in work where, on account of the inability of cores to yield, castings have come out cracked, an evil with which many founders contend. These cores are all made in halves, and after being blackened, which is done in a green state with the large cores and in a dry state with the small, they are pasted together and after being dried are then ready to be set on their ends, in the ramming pit as at W, Fig. 2. The patterns seen on the mold boards, Figs. 8 and 9, are also used for making the cores, as can be seen by a study of Fig. 7, which shows the core boxes when together and apart.

The next operation to be noted is that of pitting the molds and cores. By referring to Figs. 1 and 2, a pit 18 feet long by 8 feet wide by 2 feet 8 inches deep, is seen to be necessary for this work. After the flasks and cores are set on level beds, as at Fig. 2, sand is filled in and rammed around the mold and cores until the levels of K and W are reached, when a double row of vents are made down each side of the cores and flasks. This completed, a bed of fine cinders, as seen, is laid in between the cores and molds and also brought out to come in under the pouring basin A. These cinders are covered with straw or hay and the whole covered with sand. This done, the cores to form the gate connection G and riser E, as at Fig. 1, are placed in position. This brings the work up to a point as shown by Fig. 4. To keep dirt from dropping into the molds through the gate holes seen in the cores W, while sand is rammed between them, boards, not shown, cover the holes, and being weighted down remain stationary.

When the pit is rammed up to a level of the flasks and cores, the boards covering the cores are then removed, after which long runner patterns of the form seen at Fig. 13 are then placed over all the cores to form runners to connect with the main basin A as seen over W, Fig. 2. This done, plates are set on edge as at

M, S and X, after which the inlet plate H is set up against the plates S, and plates as at B set against its ends, after the manner shown. This completed, a board 12 inches deep by 15 feet long is braced 11 inches away from the face of H and the whole bed is then rammed up and finished to appear as seen at Fig. 5. This cut also shows men in position to test lifting the inlet plate H by means of levers Y, resting on the plate M, to come under lugs N. Stops, as at P, prevent the inlet plate being lifted to any greater height than 2½ inches, which insures only clean metal passing to the molds, as when the basin A is filled by the ladle U, as seen in Fig. 6, all dirt must be confined and remain upon the surface of the metal in the basin A. To form the basin A and its adjoining runners, separated by the inlet plate H, special care is exercised to prevent the sand forming a division between the runners at the points R, Fig. 1, from being lifted or disturbed in any manner to create dirt, when the inlet plate H is raised to let the metal flow to the molds. This is done by hoisting out the inlet plate H entirely clear of the molds before the runner patterns are drawn and shaving or trimming the sand at the rear of the inlet plate to form a clearance at the face of the runners R, as shown. By thus trimming the sand, the only back support left for the lifting plate H is that afforded by the ends of the plates S and B, which is all-sufficient, and works as nicely as could be desired. After the divisions at R between the runners have their ends trimmed off for clearance, the runner patterns are all drawn and any dust lying upon the surface of the cores, which form the bottom of the runners, is then cleaned up with a small camel's hair brush, occasionally moistened in oil, to cause the dirt to stick to it. This work completed, the inlet plate H is lowered to place and care taken to know that it has a solid bearing along the whole length and width of its bottom surface, which is three inches wide.

Two risers are carried from the two outside flasks, as at E, and left uncovered when casting so that when the molds are filled all surplus metal remaining in the basin and runners can flow out readily to pig beds having a lower level than the pouring

basin and runners as seen at C, Figs. 5 and 6, thus leaving the molds disconnected to be removed singly from their casting pit, after the gate connections between flasks at G are broken. This can be done while the connecting gates are hot or cold, as best suits the pleasure of the molder.

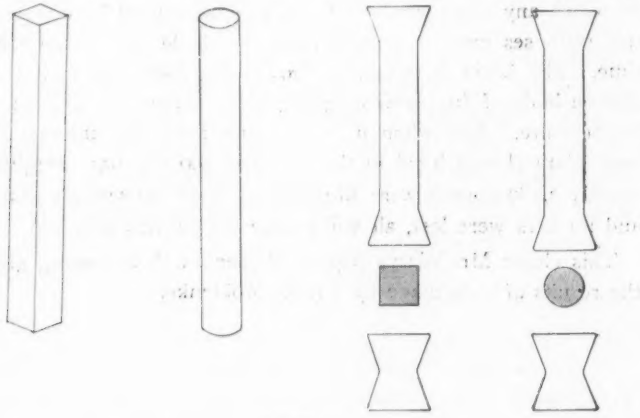
The purpose of the plan herein illustrated is to present ways by which any large number of test bars to be used for comparative purposes may be poured from one ladle and at the same time. The basin A being, as shown, one foot wide and deep, gives a body of fluid iron weighing about three tons, uniform in temperature. And when it is said that from the moment the inlet plate H was lifted to the time the 200 test bars weighing exactly 3,780 pounds were all poured, scarcely 20 seconds passed and no bars were lost, all will realize the success achieved.

This closes Mr. West's paper. Appendix B, following, gives the results of tests made by Dr. R. Moldenke.

APPENDIX B.

FORM OF TEST BARS.

Tables			Tables			Tables			Tables		
A	B	C	A	B	C	A	B	C	A	B	C
1	18	35	5	22	39	9	26	43	13	30	47
2	19	36	6	23	40	10	27	44	14	31	48
3	20	37	7	24	41	11	28	45	15	32	49
4	21	38	8	25	42	12	29	46	16	33	50



CAST A.

INGOT MOLD IRON, SOFT BESSEMER MIXTURE.

This set of 192 bars, cast vertically and at the same time, in accordance with the specifications of the American Foundrymen's Association committee on standardizing the testing of cast iron, furnished 256 test pieces and 280 separate tests.

These test bars were made by Mr. Thos. D. West and presented to the committee in the interest of the trade.

Cast A illustrates an "all pig iron" class of castings of fairly soft character, which must also show exceptional service qualities under severe, sudden heating or cooling effects causing alternate expansion and contraction strains in castings.

The composition of this cast as taken from the 1" dry sand square bar is as follows:

Total carbon	3.87
Graphite	3.44
Silicon	1.67
Manganese	.29
Phosphorus	.095
Sulphur	.032

The cross section of the square bars and the round is approximately equal for the respective sizes. The machined bars were turned or planed to the size below for purposes of comparison. In the transverse tests the supports were all 12″ apart.

FRACTURE OF CHILL TEST PIECE IN SERIES A.

The fresh fracture of each size of round and square, green sand and dry sand transverse bar was preserved, mounted in a case, and will be on exhibition at the May convention. From the physical structure of these bars it is seen that the largest

sizes for this particular kind of iron will not answer for either the standard tensile or transverse test, evidences of shrinkage spots being discernable.

But two of the smallest bars of this cast proved unserviceable, which is certainly a good showing for the method adopted.

The fluidity strips ran up full, showing good hot iron.

The chilled fractures are shown in the cut accompanying the tables.

The tabulated results of the transverse, tensile and compression tests follow, and are given for the present without further comment, the committee deeming it wise to publish the results as fast as they are available and reserving the discussion for their final report.

TABLE NO. 1.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.	Contraction. Ins.
1	.5x.5	.56	.56	310	.165	.17
2	.5x.5	.56	.56	320	.150	
3	.5x.5	.56	.57	300	.140	
4	.5x.5	.56	.59	300	.145	
5	1x1	1.09	1.06	1,980	.125	.14
6	1x1	1.10	1.03	2,050	.130	
7	1.5x1.5	1.53	1.53	6,720	.110	.12
8	1.5x1.5	1.54	1.53	6,450	.115	
9	2x2	2.06	2.04	14,050	.098	.08
10	2x2	2.02	2.04	13,820	.095	
11	2.5x2.5	2.53	2.69	25,670	.090	.08
12	2.5x2.5	2.57	2.60	26,580	.099	
13	3x3	3.01	3.04	43,110	.098	.06
14	3x3	3.03	3.02	38,880	.089	
15	3.5x3.5	3.59	3.59	56,600	.098	.04
16	3.5x3.5	3.57	3.57	60,840	.097	
17	4x4	4.09	4.11	92,020	.099	.03
18	4x4	4.08	4.07	87,920	.083	

TABLE NO. 2.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
19	1x1	.5x.5	310	.321
20	1x1	.5x.5	290	.332
21	1.5x1.5	1x1	1,570	.211
22	1.5x1.5	1x1	1,690	.234
23	2x2	1.5x1.5	5,960	.171
24	2x2	1.5x1.5	5,730	.153
25	2.5x2.5	2x2	13,290	.134
26	2.5x2.5	2x2	12,320	.118
27	3x3	2.5x2.5	23,770	.122
28	3x3	2.5x2.5	23,080	.129
29	3.5x3.5	3x3	34,380	.121
30	3.5x3.5	3x3	38,270	.121
31	4x4	3.5x3.5	50,040	.112
32	4x4	3.5x3.5	53,320	.102

TABLE NO. 3.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Actual Size. Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.	Contraction. Ins.
33	.5x.5	.56	.59	250	.175	.17
34	.5x.5	.57	.55	280	.195	
35	.5x.5	.56	.54	280	.160	
36	.5x.5	.56	.52	240	.150	
37	1x1	1.08	1.03	1,910	.140	.14
38	1x1	1.09	1.02	1,780	.135	
39	1.5x1.5	1.48	1.50	6,090	.120	.11
40	1.5x1.5	1.56	1.49	5,920	.109	
41	2x2	2.00	2.03	11,810	.103	.08
42	2x2	2.09	1.98	11,980	.118	
43	2.5x2.5	2.49	2.64	21,340	.097	.07
44	2.5x2.5	2.53	2.58	22,640	.105	
45	3x3	3.03	3.00	33,130	.106	.06
46	3x3	3.06	3.01	32,440	.105	
47	3.5x3.5	3.64	3.60	54,120	.092	.03
48	3.5x3.5	3.62	3.61	53,700	.081	
49	4x4	4.18	4.10	77,020	.079	.02
50	4x4	4.21	4.04	76,000	.086	

TABLE NO. 4.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
51	1x1	.5x.5	270	.311
52	1x1	.5x.5	260	.318
53	1.5x1.5	1x1	1,700	.251
54	1.5x1.5	1x1	1,720	.244
55	2x2	1.5x1.5	5,050	.162
56	2x2	1.5x1.5	4,890	.189
57	2.5x2.5	2x2	11,110	.129
58	2.5x2.5	2x2	11,170	.128
59	3x3	2.5x2.5	18,780	.128
60	3x3	2.5x2.5	19,090	.129
61	3.5x3.5	3x3	32,120	.119
62	3.5x3.5	3x3	30,450	.118
63	4x4	3.5x3.5	46,260	.112
64	4x4	3.5x3.5	46,170	.113

TABLE NO. 5.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Not Machined.

No.	Approx. Diameter. Ins.	Actual Size. Depth (D). Ins.	Width (D). Ins.	Breaking Strain. Lbs.	Deflection. Ins.	Contraction. Ins.
65*	.56	.60	.56	...	...	.16
66*	.56	.62	.57	...	...	
67	.56	.62	.56	430	.170	
68	.56	.62	.58	460	.175	
69	1.13	1.22	1.19	2,650	.120	.14
70	1.13	1.21	1.18	2,230	.141	
71	1.69	1.81	1.84	6,840	.140	.12
72	1.69	1.77	1.70	6,010	.132	
73	2.15	2.29	2.27	13,760	.101	.10
74	2.15	2.33	2.30	14,170	.118	
75	2.82	2.93	2.87	24,040	.095	.07
76	2.82	2.96	2.90	24,600	.108	
77	3.38	3.44	3.44	36,780	.102	.07
78	3.38	3.46	3.44	36,970	.109	
79	3.95	4.02	4.04	54,950	.086	.05
80	3.95	4.00	4.01	61,920	.095	
81	4.51	4.67	4.62	75,210	.083	.03
82	4.51	4.65	4.64	79,500	.094	

*Porous.

TABLE NO. 6.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Machined.

No.	Approx. Original Diameter. Ins.	Actual Size as Machined. D. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
83	1.13	.56	150	.305
84*	1.13	.56	...	...
85	1.69	1.13	1,910	.244
86	1.69	1.13	1,850	.225
87	2.15	1.69	5,650	.163
88	2.15	1.69	5,210	.158
89	2.82	2.15	10,010	.110
90	2.82	2.15	10,040	.118
91	3.38	2.82	18,890	.082
92	3.38	2.82	19,410	.088
93	3.95	3.38	29,650	.070
94	3.95	3.38	29,030	.074
95	4.51	3.95	50,310	.075
96	4.51	3.95	53,350	.083

*Lost in turning down.

TABLE NO. 7.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Not Machined.

No	Approx. Diameter. Ins.	Actual Size. Depth (D). Ins.	Width (D). Ins.	Breaking Strain. Lbs.	Deflection. Ins.	Contraction. Ins.
97	.56	.62	.52	220	.225	.16
98	.56	.62	.63	220	.220	
99	.56	.63	.62	230	.225	
100	.56	.58	.55	210	.220	
101	1.13	1.20	1.18	1,870	.155	.14
102	1.13	1.14	1.20	1,720	.135	
103	1.69	1.75	1.73	6,030	.130	.11
104	1.69	1.75	1.74	5,750	.126	
105	2.15	2.26	2.23	11,980	.108	.09
106	2.15	2.28	2.22	11,730	.104	
107	2.82	2.91	2.88	22,450	.108	.06
108	2.82	2.98	2.87	21,620	.102	
109	3.38	3.40	3.38	34,070	.091	.06
110	3.38	3.39	3.37	33,520	.089	
111	3.95	4.06	3.97	51,950	.087	.04
112	3.95	4.03	4.02	47,790	.081	
113	4.51	4.62	4.63	71,990	.060	.03
114	4.51	4.64	4.61	74,890	.060	

TABLE NO. 8.

Series A.

TRANSVERSE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. D. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
115	1.13	.56	160	.260
116	1.13	.56	160	.250
117	1.69	1.13	1,730	.236
118	1.69	1.13	1,860	.260
119	2.15	1.69	5,130	.165
120	2.15	1.69	5,070	.168
121	2.82	2.15	9,000	.138
122	2.82	2.15	9,190	.123
123	3.38	2.82	20,690	.081
124	3.38	2.82	21,370	.085
125	3.95	3.38	28,050	.075
126	3.95	3.38	28,650	.069
127	4.51	3.95	46,850	.068
128	4.51	3.95	45,620	.063

TABLE NO. 9.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Area in Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
129	.5x.5	.22	3,620	16,750
130	.5x.5	.21	3,280	15,620
131	.5x.5	.27	4,110	15,220
132	.5x.5	.29	4,680	16,140
133	1x1	1.09	15,200	13,940
134	1x1	.92	12,810	13,920
135	1.5x1.5	2.33	29,210	12,530
136	1.5x1.5	2,28	26,790	11,750
137	2x2	3.98	40,580	10,190
138	2x2	4.04	44,810	11,110
139	.5x.5	.31	4,620	14,900
140	.5x.5	.28	4,510	16,100
141	.5x.5	.31	4,980	16,060
142	.5x.5	.30	4,570	15,230
143	1x1	.98	13,610	13,070
144	1x1	1.00	13,420	13,420
145	1.5x1.5	2.30	27,780	12,080
146	1.5x1.5	2.29	25,120	10,970
147	2x2	4.00	42,520	10,630
148	2x2	3.87	38.990	9,820

TABLE NO. 10.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Area as Machined. Sq. Ins	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
149	1x1	.25	3,770	15,080
150	1x1	.25	3,940	15,760
151	1.5x1.5	1.00	12,860	12,860
152	1.5x1.5	1.00	13,020	13,020
153	2x2	2.25	25,900	11,510
154	2x2	2.25	23,360	10,380
155	1x1	.25	3,620	14,480
156	1x1	.25	3,840	15,360
157	1.5x1.5	1.00	12,410	12,410
158	1.5x1.5	1.00	14,640	14,640
159	2x2	2.25	24,480	10,880
160	2x2	2.25	26,510	11,780

TABLE NO. 11.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Area in Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
161	.5x.5	.27	3,910	14,480
162	.5x.5	.24	3,740	15,580
163	.5x.5	.20	2,620	13,100
164	.5x.5	.25	3,800	15,200
165	1x1	.94	12,450	13,140
166	1x1	.95	12,120	12,760
167	1.5x1.5	2.38	30,140	12,660
168	1.5x1.5	2.35	28,000	11,910
169	2x2	3.90	37,140	9,520
170	2x2	3.96	39,880	10,070
171	.5x.5	.31	4,820	15,550
172	.5x.5	.28	4,510	16,110
173	.5x.5	.30	4,980	16,600
174	.5x.5	.30	4,570	15,230
175	1x1	1.00	13,440	13,440
176	1x1	1.01	12,840	12,710
177	1.5x1.5	2.40	27,310	11,380
178	1.5x1.5	2.42	30,540	12,620
179	2x2	4.00	41,390	10,350
180	2x2	4.00	43,000	10,750

TABLE NO. 12.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Area as Machined. Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
181	1x1	.25	3,620	14,480
182	1x1	.25	3,300	13,200
183	1.5x1.5	1.00	12,990	12,990
184	1.5x1.5	1.00	13,850	13,850
185	2x2	2.25	27,060	12,030
186	2x2	2.25	27,480	12,210
187	1x1	.25	3,000	12,000
188	1x1	.25	3,240	12,960
189	1.5x1.5	1.00	12,840	12,840
190	1.5x1.5	1.00	13,140	13,140
191	2x2	2.25	24,540	10,910
192	2x2	2.25	26,100	11,600

TABLE NO. 13.

Series A.

TENSILE STRENGTH.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Not Machined.

No.	Approx. Diameter. Ins.	Actual Area in Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
193	.56	.25	3,780	15,120
194	.56	.26	4,340	16,690
195	.56	.30	4,900	16,330
196	.56	.25	3,980	15,920
197	1.13	.98	13,290	13,560
198	1.13	1.00	13,980	13,980
199	1.69	2.30	30,580	13,290
200	1.69	2.31	27,140	11,750
201	2.15	4.10	47,310	11,540
202	2.15	4.00	42,360	10,590
203	.56	.28	4,050	14,460
204	.56	.30	4,890	16,300
205	.56	.31	4,890	15,770
206	.56	.31	4,140	13,320
207	1.13	1.00	12,830	12,830
208	1.13	1.00	12,740	12,740
209	1.69	2.26	25,410	11,240
210	1.69	2.27	28,320	12,480
211	2.15	3.96	40,920	10,330
212	2.15	4.00	44,040	11,020

TABLE NO. 14.

Series A.

TENSILE STRENGTH.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Green Sand and Machined.

No.	Approx. Original Diameter. Ins.	Area as Area in Sq. Ins. Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
213	1.13	.25	3,510	14,040
214	1.13	.25	3,370	13,480
215	1.69	1.00	13,070	13,070
216	1.69	1.00	13,910	13,910
217	2.15	2.25	26,270	11,670
218	2.15	2.25	28,780	12,790
219	1.13	.25	3,650	14,600
220	1.13	.25	3,340	13,360
221	1.69	1.00	11,840	11,840
222	1.69	1.00	12,970	12,970
223	2.15	2.25	23,040	10,240
224	2.15	2.25	25,170	11,190

TABLE NO. 15.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Not Machined.

No.	Approx. Diameter. Ins.	Actual Machined.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
225	.56	.24	3,120	13,000
226	.56	.27	4,030	14,920
227	.56	.25	3,620	14,480
228	.56	.21	3,090	14,710
229	1.13	1.01	14,220	14,080
230	1.13	1.00	13,370	13,370
231	1.69	2.26	25,900	11,460
232	1.69	2.22	26,450	11,910
233	2.15	4.00	40,840	20,210
234	2.15	4.01	43,510	10,850
235	.56	.31	5,050	16,290
236	.56	.30	4,560	15,200
237	.56	.26	4,080	15,690
238	.56	.25	3,830	15,320
239	1.13	.99	13,390	13,530
240	1.13	1.00	12,910	12,910
241	1.69	2.30	28,240	12,280
242	1.69	2.34	25,110	10,690
243	2.15	4.07	42,260	10,380
244	2.15	4.04	40,040	9,900

TABLE NO. 16.

Series A.

TENSILE TEST.

Ingot Mold Iron—Soft Bessemer Mixture—Bars in Dry Sand and Machined.

No.	Approx. Original Diameter. Ins.	Area as Machined. Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength Per Sq. In. Lbs.
245	1.13	.25	3,420	13,680
246	1.13	.25	3,380	13,520
247	1.69	1.00	12,440	12,440
248	1.69	1.00	14,010	14,010
249	2.15	2.25	22,860	10,160
250	2.15	2.25	24,900	11,070
251	1.13	.25	3,690	14,760
252	1.13	.25	3,010	12,040
253	1.69	1.00	12,140	12,140
254	1.69	1.00	13,450	13,450
255	2.15	2.25	22,260	9,890
256	2.15	2.25	27,020	12,010

TABLE NO. 17.

Series A.

COMPRESSION TESTS ON ONE-HALF INCH CUBES.

Ingot Mold Iron—Soft Bessemer Mixture.

Crushing Strength in Pounds.

No.	Approx. Cross Section of Bar.	Middle Half Inch.	1st Half in. from Edge.	2nd Half in. from Edge.	3rd Half in. from Edge.	4th Half in. from Edge.
257	.5x.5	29,570	....	....	....	....
258	1x1	20,010	....	....	....	....
259	1x1	....	21,990	....	....	....
260	1.5x1.5	17,180	....	17,180	....	....
261	1.5x1.5	....	17,920	....	....	....
262	2x2	13,810	....	....	....	....
263	2x2	...	13,750	....	....	....
264	2x2	....	....	13,880	....	....
265	2.5x2.5	10,950	....	....	10,950	....
266	2.5x2.5	....	12,040	....	....	....
267	2.5x2.5	....	....	11,430	....	....
268	3x3	9,830	....	....	....	....
269	3x3	....	11,200	....	....	....
270	3x3	....	....	10,270	....	....
271	3x3	....	....	....	10,430	....
272	3.5x3.5	9,350	....	....	....	9,350
273	3.5x3.5	....	10,770	....	....	....
274	3.5x3.5	....	....	9,830	....	....
275	3.5x3.5	....	....	....	9,540	....
276	4x4	9,100	....	....	....	....
277	4x4	....	10,340	....	....	....
278	4x4	....	....	9,950	....	....
279	4x4	....	....	....	9,570	....
280	4x4	....	....	....	....	9,360

Remarks—The cubes were cut from the square bars, cast in dry sand (vertically) and were compressed along the length of the original bar.

The test pieces were cut along a line at right angles to the sides of the bars, so that all corners were avoided, except in the one-half inch bar.

For better comparison, the value of the middle cube is repeated in the table where it rounds out the series for the particular bar.

CAST B.

DYNAMO FRAME IRON.

This set of 198 bars, cast vertically and at the same time in accordance with the specifications of the American Foundrymen's Association committee on standardizing the testing of cast iron, furnished 262 test pieces and 286 separate tests. This set was presented to the committee by the Westinghouse Electric & Manufacturing Co. in the interest of the trade. The cast was made by Mr. Jos. S. McDonald.

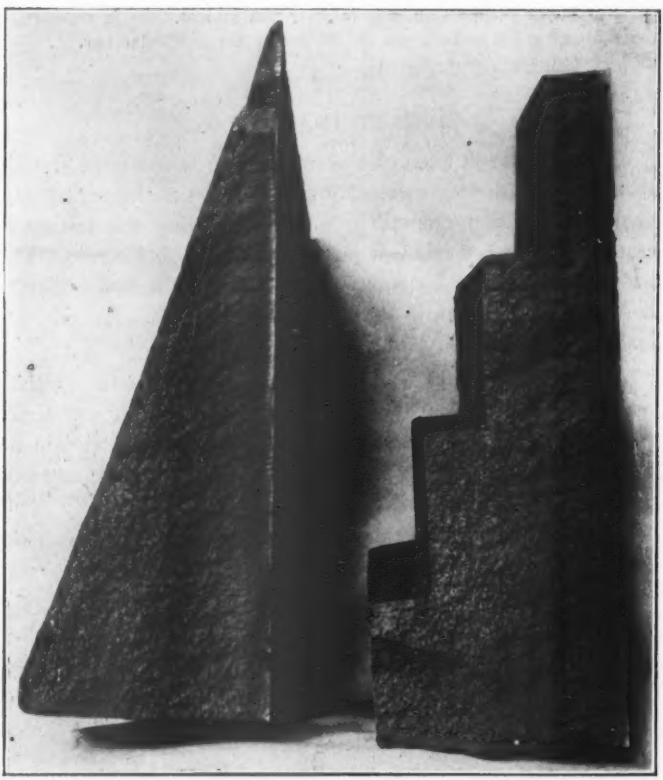
Cast B illustrates a class of castings which must machine readily, be soft in sections little over ½" thick, and yet sound when 14" is reached. About 45 per cent scrap is carried in the mixture. A good transverse strength and resilience is essential, tensile strength being less so.

The composition of this cast as taken from the 1-inch dry sand square bar is as follows:

Total carbon	3.82
Graphite	3.23
Silicon	1.95
Manganese	.39
Phosphorus	.405
Sulphur	.042

The cross section of the square bars and the round is approximately equal for the relative sizes. The machined bars were turned or planed to the size below for purposes of comparison. In the transverse tests the supports were all 12 inches apart. The fresh fracture of each size of round and square, green sand and dry sand transverse bar was preserved and mounted in a case, and was on exhibition at the convention of the A. F. A. in

Pittsburg. From the physical structure of these bars it is seen that the larger sizes would be much better available for standard tests than was the case with Series A, shrinkage spots not being



FRACTURE OF CHILL TEST PIECE IN SERIES B.

very much in evidence. However, there is a slight tendency to pipe, a circumstance fatal to the value of a test bar cast in any other position than the vertical. But two bars proved unserviceable. The fluidity strips ran up nearly full. The chilled fractures are shown in the cut accompanying the tables.

TABLE NO. 18.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Green Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
281	.5x.5	.53	.57	380	.190
282	.5x.5	.52	.53	320	.200
283	.5x.5	.54	.56	460	.210
284	.5x.5	.54	.55	340	.190
285	1x1	1.04	1.04	2,140	.130
286	1x1	1.01	1.03	2,580	.110
287	1.5x1.5	1.52	1.52	8,060	.102
288	1.5x1.5	1.57	1.53	7,920	.102
289	2x2	2.03	2.04	16,180	.101
290	2x2	2.01	2.03	14,920	.087
291	2.5x2.5	2.57	2.59	30,500	.103
292	2.5x2.5	2.51	2.50	27,680	.101
293	3x3	3.03	3.02	45,790	.099
294	3x3	3.03	3.02	45,660	.102
295	3.5x3.5	3.52	3.54	68,470	.091
296	3.5x3.5	3.57	3.56	70,140	.092
297	4x4	4.00	4.06	over 100,000	*
298	4x4	4.02	4.05	over 100,000	**

* .055 in. at 100,000 lbs.

** .056 in. at 100,000 lbs.

TABLE NO. 19.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Green Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
299	1x1	.5x.5	250	.299
300	1x1	.5x.5	270	.281
301	1.5x1.5	1x1	2,080	.170
302	1.5x1.5	1x1	2,400	.159
303	2x2	1.5x1.5	6,640	.142
304	2x2	1.5x1.5	6,390	.146
305	2.5x2.5	2x2	15,390	.119
306	2.5x2.5	2x2	16,400	.116
307	3x3	2.5x2.5	27,770	.106
308	3x3	2.5x2.5	28,460	.091
309	3.5x3.5	3x3	44,070	.093
310	3.5x3.5	3x3	46,180	.090
311	4x4	3.5x3.5	66,240	.052
312	4x4	3.5x3.5	63,100	.059

TABLE NO. 20.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
313	.5x.5	.53	.53	320	.220
314	.5x.5	.50	.56	340	.230
315	.5x.5	.52	.52	280	.190
316	.5x.5	.55	.56	240	.160
317	1x1	1.07	1.01	2,300	.110
318	1x1	1.05	1.06	2,660	.105
319	1.5x1.5	1.55	1.54	7,470	.100
320	1.5x1.5	1.58	1.53	7,100	.091
321	2x2	2.01	2.03	16,100	.087
322	2x2	2.07	2.03	16,230	.091
323	2.5x2.5	2.56	2.51	27,840	.112
324	2.5x2.5	2.51	2.54	29,800	.105
325	3x3	3.09	3.10	49,360	.102
326	3x3	3.00	3.06	46,050	.100
327	3.5x3.5	3.58	3.61	74,920	.090
328	3.5x3.5	3.62	3.53	72,450	.091
329	4x4	4.15	4.00	99,650	.069
330	4x4	4.16	4.02	99,820	.072

TABLE NO. 21.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
331	1x1	.5x.5	220	.300
332	1x1	.5x.5	200	.294
333	1.5x1.5	1x1	2,020	.182
334	1.5x1.5	1x1	2,000	.180
335	2x2	1.5x1.5	6,470	.123
336	2x2	1.5x1.5	6,000	.130
337	2.5x2.5	2x2	15,840	.118
338	2.5x2.5	2x2	15,430	.114
339	3x3	2.5x2.5	25,840	.103
340	3x3	2.5x2.5	27,780	.100
341	3.5x3.5	3x3	43,000	.086
342	3.5x3.5	3x3	41,370	.082
343	4x4	3.5x3.5	60,620	.051
344	4x4	3.5x3.5	62,510	.049

Series B.

TABLE NO. 22.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Green Sand and Not Machined.

No.	Approx. Diameter.	Actual size. Depth (D).	Width (D).	Breaking Strain.	Deflection.
		Ins.	Ins.	Lbs.	Ins.
345	.56	.59	.52	250	.100
346*	.56	...	...	...	....
347	.56	.58	.59	220	.106
348	.56	.56	.58	200	.107
349	1.13	1.17	1.18	2,490	.120
350	1.13	1.15	1.18	2,120	.130
351	1.69	1.74	1.74	7,130	.081
352	1.69	1.73	1.74	7,020	.077
353	2.15	2.26	2.26	15,680	.083
354	2.15	2.26	2.27	15,880	.089
355	2.82	2.86	2.84	31,770	.102
356	2.82	2.84	2.89	31,170	.100
357	3.38	3.53	3.48	46,790	.098
358	3.38	3.44	3.41	49,620	.091
359	3.95	4.01	4.02	71,440	.095
360	3.95	4.01	4.00	75,660	.092
361	4.51	4.61	4.64	100,120	.061
362	4.51	4.62	4.62	over 100,000	**

* Defective—shot.

** .044 inch at 100,000 lbs.

Series B.

TABLE NO. 23.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Green Sand and Machined.

No.	Approx. Original Diameter.	Actual Diam. as Machined.	Breaking Strain.	Deflection.
	Ins.	Ins.	Lbs.	Ins.
363	1.13	.56	230	.310
364	1.13	.56	230	.302
365	1.69	1.13	2,040	.168
366	1.69	1.13	2,190	.152
367	2.15	1.69	6,170	.113
368	2.15	1.69	6,070	.118
369	2.82	2.15	11,040	.079
370	2.82	2.15	11,090	.082
371	3.38	2.82	23,530	.092
372	3.38	2.82	24,830	.098
373	3.95	3.38	41,520	.072
374	3.95	3.38	41,050	.074
375	4.51	3.95	66,090	.069
376	4.51	3.95	64,210	.061

TABLE NO. 24.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Not Machined.

No.	Approx. Diameter.	Actual Size. Depth (D).	Width (D).	Breaking Strain.	Deflection.	Contraction.
377	.56	.52	.58	200	.204	
378	.56	.58	.60	190	.203	
379	.56	.53	.60	200	.190	
380	.56	.51	.58	180	.220	
381	1.13	1.18	1.13	2,610	.110	
382	1.13	1.14	1.12	2,240	.120	
383	1.61	1.77	1.74	8,080	.085	
384	1.61	1.72	1.74	7,480	.082	
385	2.15	2.34	2.29	15,620	.087	.12
386	2.15	2.26	2.26	15,260	.078	
387	2.82	2.87	2.89	31,900	.107	
388	2.82	2.86	2.84	30,770	.111	
389	3.38	3.42	3.44	48,280	.093	
390	3.38	3.48	3.49	47,810	.089	
391	3.95	3.97	4.02	72,530	.095	
392	3.95	3.99	4.02	74,400	.094	
393	4.51	4.60	4.62	over 100,000	*	
394	4.51	4.60	4.62	over 100,000	**	

* .040 inch at 100,000 lbs.
** .044 inch at 100,000 lbs.

TABLE NO. 25.

Series B.

TRANSVERSE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Diameter. Ins.	Actual Diameter as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
395	1.13	.56	210	.311
396	1.13	.56	240	.320
397	1.69	1.13	1,820	.178
398	1.69	1.13	1,750	.162
399	2.15	1.69	5,880	.114
400	2.15	1.69	6,030	.112
401	2.82	2.15	11,220	.088
402	2.82	2.15	10,840	.091
403	3.38	2.82	23,740	.089
404	3.38	2.82	24,420	.088
405	3.95	3.38	39,220	.075
406	3.95	3.38	39,570	.078
407	4.51	3.95	62,880	.052
408	4.51	3.95	63,120	.058

TABLE NO. 26.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Green Sand and not Machined.

No.	Approximate Cross Section. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength per Sq. Inch in Lbs.
409	.5x.5	.28	4,910	17,540
410	.5x.5	.29	4,920	17,600
411	.5x.5	.26	4,440	17,080
412	.5x.5	.28	4,490	16,180
413	1x1	1.01	15,900	15,740
414	1x1	1.04	15,150	14,570
415	1.5x1.5	2.26	28,450	12,590
416	1.5x1.5	2.24	29,470	13,150
417	2x2	4.02	47,930	11,920
418	2x2	4.01	45,120	11,000
419	.5x.5	.30	5,050	16,830
420	.5x.5	.31	4,990	16,100
421	.5x.5	.31	5,030	16,220
422	.5x.5	.29	4,650	16,030
423	1x1	1.01	15,700	15,540
424	1x1	1.04	14,980	14,400
425	1.5x1.5	2.30	30,280	13,170
426	1.5x1.5	2.31	31,090	13,460
427	2x2	3.97	41,030	10,330
428	2x2	3.97	42,480	10,700

TABLE NO. 27.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Green Sand and Machined.

No.	Approx. Original Cross. Section. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength per Sq. Inch in Lbs.
429	1x1	.25	4,790	19,160
430	1x1	.25	4,020	16,080
431	1.5x1.5	1.00	14,220	14,220
432	1.5x1.5	1.00	15,790	15,790
433	2x2	2.25	24,930	11,080
434	2x2	2.25	32,580	14,480
435	1x1	.25	4,030	16,120
436	1x1	.25	4,860	19,440
437	1.5x1.5	1.00	15,360	15,360
438	1.5x1.5	1.00	14,580	14,580
439	2x2	2.25	25,970	11,540
440	2x2	2.25	28,720	12,760

TABLE NO. 28.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Not Machined.

No.	Approximate Cross Section. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength per Sq. Inch in Lbs.
441	.5x.5	.27	4,510	16,700
442	.5x.5	.30	4,840	16,130
443	.5x.5	.29	4,840	16,700
444	.5x.5	.28	4,440	15,710
445	1x1	1.03	15,120	14,680
446	1x1	1.03	15,480	15,030
447	1x1	1.02	15,550	15,240
448	1x1	1.01	15,570	15,410
449	1.5x1.5	2.25	29,150	12,950
450	1.5x1.5	2.27	30,980	13,640
451	2x2	3.92	41,940	11,210
452	2x2	3.98	43,810	11,060
453	.5x.5	.28	4,420	15,800
454	.5x.5	.25	4,150	16,600
455	.5x.5	.27	4,280	15,850
456	.5x.5	.28	4,090	14,610
457	1x1	1.03	15,320	14,870
458	1x1	1.09	16,700	15,320
459	1x1	1.04	15,790	15,180
460	1.5x1.5	2.24	28,840	12,870
461	1.5x1.5	2.23	26,650	10,610
462	2x2	4.00	45,480	11,370
463*	2x2	....	.....	.....

*Dirty iron.

TABLE NO. 29.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
464	1x1	.25	4,460	17,840
465	1x1	.25	4,750	19,000
466	1.5x1.5	1.00	14,690	14,690
467	1.5x1.5	1.00	15,180	15,180
468	2x2	2.25	26,000	11,560
469	2x2	2.25	28,460	12,650
470	1x1	.25	3,990	15,960
471	1x1	.25	4,200	16,800
472	1.5x1.5	1.00	15,330	15,330
473	1.5x1.5	1.00	12,940	12,940
474	2x2	2.25	25,920	11,520
475	2x2	2.25	28,530	12,680

TABLE NO. 30.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Green Sand and Not Machined.

No.	Approx. Original Diameter. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
476	.56	.25	4,020	16,080
477	.56	.25	4,410	17,640
478	.56	.26	4,280	16,000
479	.56	.28	4,600	16,430
480	1.13	.96	15,220	15,860
481	1.13	1.00	15,870	15,870
482	1.69	2.26	28,590	13,090
483	1.69	2.26	29,700	13,140
484	2.15	4.03	47,040	11,670
485	2.15	4.05	46,120	11,140
486	.56	.26	4,450	17,110
487	.56	.26	4,170	16,040
488	.56	.26	4,170	16,040
489	.56	.28	4,380	15,650
490	1.13	1.00	15,310	15,310
491	1.13	.99	14,180	14,320
492	1.69	2.26	30,380	13,440
493	1.69	2.31	32,260	13,970
494	2.15	4.00	42,200	10,550
495	2.15	4.14	50,180	12,120

TABLE NO. 31.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Green Sand and Machined.

No.	Approx. Original Diameter. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
496	1.13	.25	4,810	19,240
497	1.13	.25	4,690	18,760
498	1.69	1.00	14,760	14,760
499	1.69	1.00	15,990	15,990
500	2.15	2.25	27,900	12,400
501	2.15	2.25	26,510	12,670
502	1.13	.25	4,220	16,880
503	1.13	.25	4,800	19,200
504	1.69	1.00	14,340	14,340
505	1.69	1.00	13,400	13,400
506	2.15	2.25	30,910	13,740
507	2.15	2.25	30,950	13,760

TABLE NO. 32.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Not Machined.

No.	Approx. Original Diameter. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
508	.56	.26	4,090	15,730
509	.56	.24	4,000	16,670
510	.56	.24	4,170	17,790
511*	.56	...	.....	.....
512	1.13	1.01	16,650	16,480
513	1.13	.96	14,850	15,470
514	1.13	1.02	16,700	16,370
515	1.69	2.27	30,240	13,320
516	1.69	2.25	29,220	13,000
517	2.15	4.03	44,780	11,110
518	2.15	4.00	43,650	10,910
519	.56	.25	4,450	17,800
520	.56	.26	4,190	16,110
521	.56	.27	4,280	15,810
522	.56	.20	3,520	17,600
523	1.13	1.03	16,650	16,160
524	1.13	1.02	16,340	16,510
525	1.13	1.10	17,790	16,170
526	1.13	1.14	18,470	16,200
527	1.69	2.33	34,590	14,840
528	1.69	2.27	30,640	13,500
529	2.15	4.09	46,680	11,410
530	2.15	4.01	43,210	10,770

*Lost.

TABLE NO. 33.

Series B.

TENSILE TEST.

Dynamo Frame Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Diameter. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
531	1.13	.25	4,390	17,560
532	1.13	.25	4,040	16,160
533	1.69	1.00	15,780	15,780
534	1.69	1.00	14,400	14,400
535	2.15	2.25	29,280	13,010
536	2.15	2.25	29,740	13,220
537	1.13	.25	4,670	18,680
538	1.13	.25	4,000	16,000
539	1.69	1.00	15,770	15,770
540	1.69	1.00	13,940	13,940
541	2.15	2.25	28,570	12,700
542	2.15	2.25	31,010	13,790

TABLE NO. 34.

Series B.

COMPRESSION TEST—ONE-HALF INCH CUBES.

Dynamo Frame Iron.

Crushing Strength in Pounds.

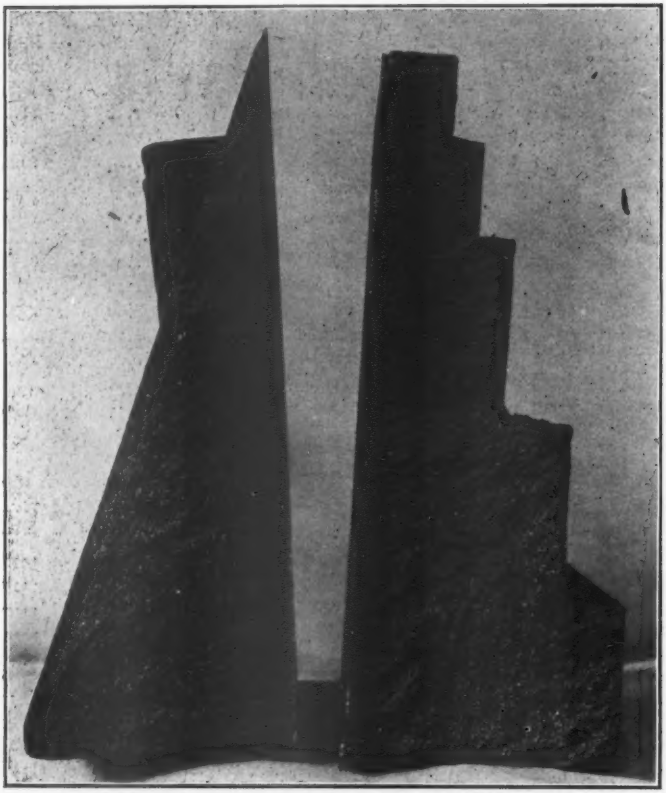
No.	Approx. Cross Section of Bar.	Middle Half Inch.	1st Half Inch from Edge.	2nd Half Inch from Edge.	3rd Half Inch from Edge.	4th Half Inch from Edge.
543	.5x.5	38,360	....	....	....	....
544	1x1	23,000	....	....	....	....
545	1x1	....	27,440	....	....	....
546	1.5x1.5	20,980	....	20,980	....	....
547	1.5x1.5	....	24,820	....	....	....
548	2x2	18,130	....	....	....	....
549	2x2	....	21,640	....	....	....
550	2x2	....	....	18,740	....	....
551	2.5x2.5	15,060	....	....	15,060	....
552	2.5x2.5	....	18,270	....	....	....
553	2.5x2.5	....	....	15,940	....	....
554	3x3	13,790	....	....	....	....
555	3x3	....	17,000	....	....	....
556	3x3	....	....	14,410	....	....
557	3x3	....	....	....	13,900	....
558	3.5x3.5	13,160	....	....	....	13,160
559	3.5x3.5	....	15,970	....	....	....
560	3.5x3.5	....	....	15,200	....	....
561	3.5x3.5	....	....	....	13,560	....
562	4x4	12,430	....	....	....	....
563	4x4	....	16,140	....	....	....
564	4x4	....	....	13,950	....	....
565	4x4	....	....	....	13,760	....
566	4x4	....	....	....	....	12,830

Remarks.—The cubes were cut from the square bars, cast in dry sand (vertically), and were compressed along the length of the original bar. Test pieces were cut along a line at right angles to the sides of the bar. The value of the middle cube is repeated where it rounds out the series.

CAST C.

LIGHT MACHINERY IRON.

This set of 193 bars, cast vertically and at the same time, in accordance with the specifications of the American Foundrymen's Association committee on standardizing the testing of



FRACTURE OF CHILL TEST PIECE IN SERIES C.

cast iron, furnished 257 test pieces and 281 separate tests. This set was presented to the committee by the Westinghouse Electric & Manufacturing Co. in the interest of the trade. The cast was made by Messrs. Jos. S. McDonald and Benj. D. Fuller.

Cast C illustrates a class of castings which must be made with metal fluid enough to run into very thin sections and yet be soft enough to machine readily. A good transverse and tensile strength is essential. About 40 per cent scrap is carried in the mixture. The composition as taken from the 1-inch dry sand square bar is as follows:

Total carbon	3.84
Graphite	3.52
Silicon	2.04
Manganese	.39
Phosphorus	.578
Sulphur	.044

The cross section of the square bars and the round is approximately equal for the relative sizes. The machined bars were turned or planed to the size below for purposes of comparison. In the transverse tests the supports were all 12 inches apart. The fresh fracture of each size of round and square, green sand and dry sand transverse bar was preserved, and were on exhibition at the convention of the A. F. A. in Pittsburg.

From the fractures of the bars it is seen that the tendency to pipe is very strongly marked, the heaviest sections in some cases having fully developed pipes, the encircling walls being composed of white segregated (probably high phosphorus) material. All bars of the cast were serviceable and no tests were lost. The fluidity strips ran up full, and the chilled fractures are shown in the cut accompanying the tables.

TABLE NO. 35.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Green Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
567	.5x.5	.54	.53	360	.181
568	.5x.5	.52	.56	330	.161
569	.5x.5	.56	.56	430	.204
570	.5x.5	.54	.56	320	.170
571	1x1	1.01	1.01	1,960	.101
572	1x1	1.03	1.02	2,390	.099
573	1.5x1.5	1.53	1.53	7,070	.099
574	1.5x1.5	1.57	1.51	6,520	.081
575	2x2	2.04	2.04	16,620	.099
576	2x2	2.02	2.03	17,030	091
577	2.5x2.5	2.54	2.52	28,430	.062
578	2.5x2.5	2.54	2.55	27,350	.053
579	3x3	3.00	3.01	46,170	.073
580	3x3	3.00	3.02	47,260	.062
581	3.5x3.5	3.51	3.55	73,020	.072
582	3.5x3.5	3.52	3.54	71,900	.064
583	4x4	4.00	4.04	102,640	.058
584	4x4	4.01	4.02	over 105,000	*

* .042 inches at 105,000 lbs.

TABLE NO. 36.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Green Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
585	1x1	.5x.5	730	.289
586	1x1	.5x.5	680	.299
587	1.5x1.5	1x1	2,060	.149
588	1.5x1.5	1x1	2,410	.143
589	2x2	1.5x1.5	6,920	.125
590	2x2	1.5x1.5	6,950	.120
591	2.5x2.5	2x2	15,040	.094
592	2.5x2.5	2x2	14,980	.098
593	3x3	2.5x2.5	28,440	.082
594	3x3	2.5x2.5	29,370	.077
595	3.5x3.5	3x3	49,100	.073
596	3.5x3.5	3x3	47,850	.075
597	4x4	3.5x3.5	67,570	.068
598	4x4	3.5x3.5	65,140	.071

TABLE NO. 37.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Dry Sand and Not Machined.

No.	Approx. Cross Section. Ins.	Actual Size. Depth. Ins.	Width. Ins.	Breaking Strain. Lbs.	Deflection. Ins.	Contraction in 12 Inches. Ins.
599	.5x.5	.52	.52	390	.209	..
600	.5x.5	.54	.50	360	.184	..
601	.5x.5	.54	.53	390	.188	..
602	.5x.5	.51	.51	380	.182	..
603	1x1	1.02	1.01	2,260	.148	..
604	1x1	1.03	1.02	2,380	.143	..
605	1.5x1.5	1.52	1.57	7,960	.079	.15
606	1.5x1.5	1.52	1.58	7,720	.086	
607	2x2	2.01	2.04	16,200	.081	.13
608	2x2	2.04	2.03	16,040	.082	..
609	2.5x2.5	2.54	2.52	27,940	.099	.09
610	2.5x2.5	2.56	2.54	29,020	.092	..
611	3x3	3.04	3.10	45,740	.085	.07
612	3x3	3.03	3.04	46,080	.082	..
613	3.5x3.5	3.56	3.50	72,200	.091	.04
614	3.5x3.5	3.52	3.54	70,650	.080	..
615	4x4	4.00	4.10	101,460	.070	.03
616	4x4	4.02	4.12	102,520	.062	..

TABLE NO. 38.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Ins.	Actual Size as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
617	1x1	.5x.5	650	.318
618	1x1	.5x.5	670	.298
619	1.5x1.5	1x1	2,200	.131
620	1.5x1.5	1x1	2,120	1.34
621	2x2	1.5x1.5	6,680	.112
622	2x2	1.5x1.5	6,600	.118
623	2.5x2.5	2x2	14,320	.107
624	2.5x2.5	2x2	15,470	.110
625	3x3	2.5x2.5	27,300	.082
626	3x3	2.5x2.5	29,490	.084
627	3.5x3.5	3x3	44,780	.075
628	3.5x3.5	3x3	46,440	.079
629	4x4	3.5x3.5	61,430	.079
630	4x4	3.5x3.5	60,110	.075

TABLE NO. 39.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Green Sand and Not Machined.

No.	Approx. Diameter. Ins.	Actual Size. Depth. Ins. D.	Actual Size. Width. Ins. D.	Breaking Strain. Lbs.	Deflection. Ins.
631	.56	.57	.57	390	.138
632	.56	.56	.56	380	.168
633	.56	.56	.56	380	.151
634	.56	.56	.56	310	.158
635	1.13	1.13	1.14	2,430	.139
636	1.13	1.13	1.15	2,210	.099
637	1.69	1.75	1.75	6,690	.084
638	1.69	1.75	1.75	7,190	.094
639	2.15	2.28	2.28	17,060	.082
640	2.15	2.26	2.27	15,610	.075
641	2.82	2.81	2.84	29,820	.083
642	2.82	2.87	2.84	32,240	.093
643	3.38	3.42	3.44	49,770	.079
644	3.38	3.43	3.42	50,630	.068
645	3.95	3.97	3.97	70,330	.067
646	3.95	4.00	3.96	74,030	.067
647	4.51	4.62	4.64	105,010	.041
648	4.51	4.61	4.65	103,930	.047

TABLE NO. 40.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Green Sand and Machined.

No.	Approx. Original Diameter. Ins.	Actual Diam. as Machined. Ins.	Breaking Strain. Lbs.	Deflection. Ins.
649	1.13	.56	310	.299
650	1.13	.56	330	.312
651	1.69	1.13	2,200	.129
652	1.69	1.13	2,270	.131
653	2.15	1.69	6,790	.113
654	2.15	1.69	6,770	.111
655	2.82	2.15	12,640	.095
656	2.82	2.15	12,350	.098
657	3.38	2.82	27,020	.082
658	3.38	2.82	26,580	.089
659	3.95	3.38	42,790	.088
660	3.95	3.38	43,510	.083
661	4.51	3.95	71,460	.078
662	4.51	3.95	73,930	.072

TABLE NO. 41.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Dry Sand and Not Machined.

No.	Approximate. Diameter.	Actual Size. Depth (D).	Width (D).	Breaking Strain.	Deflection.
663	.56	.57	.58	320	.160
664	.56	.57	.56	310	.149
665	.56	.60	.56	360	.141
666	.56	.62	.57	380	.142
667	1.13	1.14	1.18	2,540	.118
668	1.13	1.12	1.16	2,390	.122
669	1.69	1.73	1.72	7,610	.098
670	1.69	1.73	1.73	7,240	.098
671	2.15	2.27	2.30	15,610	.079
672	2.15	2.26	2.26	15,140	.087
673	2.82	2.86	2.81	30,270	.079
674	2.82	2.86	2.82	30,440	.078
675	3.38	3.48	3.42	51,910	.083
676	3.38	3.44	3.49	50,350	.088
677	3.95	3.97	3.97	71,090	.083
678	3.95	3.97	3.98	73,400	.084
679	4.51	4.64	4.67	104,770	.040
680	4.51	4.61	4.69	over 105,000	*

* .042 inch at 105,000 lbs.

TABLE NO. 42.

Series C.

TRANSVERSE TEST.

Light Machinery Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Diameter. Inches.	Actual Diameter as Machined. Inches.	Breaking Strain. Lbs.	Deflection. Inches.
681	1.13	.56	280	.338
682	1.13	.56	270	.351
683	1.69	1.13	2,460	.132
684	1.69	1.13	2,390	.148
685	2.15	1.69	5,550	.118
686	2.15	1.69	6,440	.113
687	2.82	2.15	12,660	.099
688	2.82	2.15	12,680	.108
689	3.38	2.82	26,600	.093
690	3.38	2.82	26,660	.097
691	3.95	3.38	40,920	.086
692	3.95	3.38	40,590	.082
693	4.51	3.95	68,650	.077
694	4.51	3.95	66,540	.072

TABLE NO. 43.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Green Sand and Not Machined.

No.	Approximate Cross Section. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
695	.5x.5	.25	4,580	18,320
696	.5x.5	.25	4,740	18,960
697	.5x.5	.28	4,420	15,790
698	.5x.5	.27	4,790	17,740
699	1x1	1.00	16,810	16,810
700	1x1	1.04	15,990	15,370
701	1x1	1.03	16,360	15,880
702	1.5x1.5	2.24	26,910	12,010
703	1.5x1.5	2.25	29,260	13,030
704	2x2	4.01	45,020	11,230
705	2x2	4.04	43,960	10,880
706	.5x.5	.25	4,080	16,320
707	.5x.5	.24	3,920	16,330
708	.5x.5	.23	4,090	17,780
709	.5x.5	.28	4,280	15,290
710	1x1	1.00	15,490	15,490
711	1x1	1.01	16,620	16,450
712	1.5x1.5	2.29	26,230	11,450
713	1.5x1.5	2.31	27,440	11,880
714	2x2	4.12	44,540	10,810
715	2x2	4.10	43,970	10,720

TABLE NO. 44.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Green Sand and Machined.

No.	Approx. Original Cross Section. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength Lbs. per Sq. Inch.
716	1x1	.25	4,840	19,360
717	1x1	.25	4,390	17,560
718	1.5x1.5	1.00	14,770	14,770
719	1.5x1.5	1.00	15,490	15,490
720	2x2	2.25	26,890	12,390
721	2x2	2.25	24,640	10,950
722	1x1	.25	4,480	17,920
723	1x1	.25	4,340	17,360
724	1.5x1.5	1.00	12,990	12,990
725	1.5x1.5	1.00	15,070	15,070
726	2x2	2.25	26,550	11,800
727	2x2	2.25	21,120	9,390

TABLE NO. 45.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Dry Sand and Not Machined.

No.	Approximate Cross Section. Inches.	Actual Area in Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
728	.5x.5	.24	3,820	15,910
729	.5x.5	.25	4,010	16,040
730	.5x.5	.24	3,940	16,420
731	.5x.5	.25	4,260	17,040
732	1x1	1.01	16,220	16,060
733	1x1	1.01	16,140	15,980
734	1.5x1.5	2.21	24,910	11,270
735	1.5x1.5	2.23	29,140	13,070
736	2x2	4.00	44,020	11,000
737	2x2	4.02	46,750	11,630
738	.5x.5	.23	3,920	17,040
739	.5x.5	.23	3,860	16,780
740	.5x.5	.26	4,280	16,460
741	.5x.5	.27	4,540	16,810
742	1x1	1.00	15,450	15,450
743	1x1	1.01	16,280	16,120
744	1.5x1.5	2.26	27,720	12,260
745	1.5x1.5	2.28	30,230	13,260
746	2x2	4.08	44,100	10,810
747	2x2	4.10	44,960	10,970

TABLE NO. 46.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Cross Section. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
748	1x1	.25	4,080	16,320
749	1x1	.25	4,460	17,840
750	1.5x1.5	1.00	14,350	14,350
751	1.5x1.5	1.00	13,900	13,900
752	2x2	2.25	20,980	9,320
753	2x2	2.25	23,000	10,220
754	1x1	.25	4,690	18,760
755	1x1	.25	4,860	19,440
756	1.5x1.5	1.00	14,270	14,270
757	1.5x1.5	1.00	12,510	12,510
758	2x2	2.25	28,650	13,730
759	2x2	2.25	27,100	12,040

TABLE NO. 47.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Green Sand and Not Machined.

No.	Approx. Original Diameter. Inches.	Actual Area in Sq. Inch.	Breaking Strain Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
760	.56	.28	4,650	16,610
761	.56	.27	4,910	18,180
762	.56	.27	4,830	17,890
763	.56	.25	4,660	18,640
764	1.13	1.00	16,420	16,420
765	1.13	1.00	15,310	15,310
766	1.69	2.27	31,570	13,910
767	1.69	2.25	32,470	14,430
768	2.15	4.06	49,570	12,210
769	2.15	4.04	47,890	11,850
770	.56	.25	4,670	18,680
771	.56	.23	3,920	17,040
772	.56	.25	4,200	16,800
773	.56	.24	3,980	16,580
774	1.13	.97	16,190	16,690
775	1.13	.98	16,060	16,380
776	1.69	2.33	32,610	14,000
777	1.69	2.38	35,290	14,820
778	2.15	4.10	48,140	11,740
779	2.15	4.04	48,000	11,880

TABLE NO. 48.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Green Sand and Machined.

No.	Approx. Original Diameter. Inches.	Area as Machined. Sq. Inches.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
780	1.13	.25	4,510	18,040
781	1.13	.25	4,180	16,720
782	1.69	1.00	15,280	15,280
783	1.69	1.00	14,700	14,700
784	2.15	2.25	25,440	11,300
785	2.15	2.25	26,630	11,840
786	1.13	.25	4,050	16,200
787	1.13	.25	4,720	18,880
788	1.69	1.00	16,120	16,120
789	1.69	1.00	15,260	15,260
790	2.15	2.25	28,970	14,210
791	2.15	2.25	23,000	10,220

TABLE NO. 49.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Dry Sand and Not Machined.

No.	Approx. Original Diameter. Inches.	Actual Area in Sq. Inches.	Breaking Strain Lbs.	Ultimate Strength. Lbs. per Sq. Inch.
792	.56	.25	4,080	16,320
793	.56	.25	4,140	16,560
794	.56	.24	3,830	15,960
795	.56	.26	4,360	16,770
796	1.13	.98	14,980	15,280
797	1.13	1.01	16,750	16,580
798	1.69	2.26	30,700	13,590
799	1.69	2.29	33,220	14,500
800	2.15	4.01	46,060	11,480
801	2.15	4.00	46,800	11,700
802	.56	.20	3,820	19,100
803	.56	.22	3,740	17,000
804	.56	.22	3,960	18,000
805	.56	.23	3,980	17,300
806	1.13	1.01	15,800	15,640
807	1.13	.99	16,370	16,540
808	1.69	2.22	24,710	11,130
809	1.69	2.38	34,000	14,280
810	2.15	4.10	45,200	11,020
811	2.15	4.02	43,900	10,920

TABLE NO. 50.

Series C.

TENSILE TEST.

Light Machinery Iron—Bars in Dry Sand and Machined.

No.	Approx. Original Diameter. Ins.	Area as Machined. Sq. Ins.	Breaking Strain. Lbs.	Ultimate Strength. Lbs. Per Sq. In.
812	1.13	.25	4,490	17,960
813	1.13	.25	4,370	17,480
814	1.69	1.00	15,120	15,120
815	1.69	1.00	16,580	16,580
816	2.15	2.25	24,300	10,800
817	2.15	2.25	22,640	10,060
818	1.13	.25	4,540	18,160
819	1.13	.25	4,690	18,760
820	1.69	1.00	13,900	13,900
821	1.69	1.00	15,950	15,950
822	2.15	2.25	21,970	9,760
823	2.15	2.25	24,080	10,700

TABLE NO. 51.

Series C.

COMPRESSION TEST—ONE-HALF INCH CUBES.

Light Machinery Iron.

Crushing Strength in Pounds.

No.	Approximate Cross Sec. of Bar—Ins.	Middle half-inch.	1st half-inch from edge.	2nd half-inch from edge.	3rd half-inch from edge.	4th half-inch from edge.
824	.5x.5	38,500	.....	.....	.....	.....
825	1x1	24,890	.....	.....	.....	.....
826	1x1	.....	27,900	.....	.....	.....
827	1.5x1.5	20,750	.....	20,750	.....	.....
828	1.5x1.5	.....	22,060	.....	.....	.....
829	2x2	18,010	.....	.....	.....	.....
830	2x2	.....	21,750	.....	.....	.....
831	2x2	.....	.....	19,340	.....	.....
832	2.5x2.5	17,840	.....	.....	17,840	.....
833	2.5x2.5	.....	19,800	.....	.....	.....
834	2.5x2.5	.....	.....	18,050	.....	.....
835	3x3	15,950	.....	.....	.....	.....
836	3x3	.....	18,170	.....	.....	.....
837	3x3	.....	.....	16,850	.....	.....
838	3x3	.....	.....	.....	16,040	.....
839	3.5x3.5	15,880	.....	.....	.....	15,880
840	3.5x3.5	.....	17,100	.....	.....	.....
841	3.5x3.5	.....	.....	16,510	.....	.....
842	3.5x3.5	.....	.....	.....	16,080	.....
843	4x4	14,220	.....	.....	.....	.....
844	4x4	.....	16,410	.....	.....	.....
845	4x4	.....	.....	15,250	.....	.....
846	4x4	.....	.....	.....	14,880	.....
847	4x4	.....	.....	.....	.....	14,200

The cubes were cut from the square bars cast in dry sand (vertically) and were compressed along the length of the original bar. Test pieces were cut along a line at right angles to the sides of the bar. The value of the middle cube is repeated when it rounds out the series.

DISCUSSION.

Mr. Bell: I think it is now in order to accept this report and that the committee be continued. What is your wish in this matter?

Mr. Keep: I was not aware that it was necessary to continue this committee, as I understood that it was a permanent

part of the Association. I move that the report be accepted and this committee be continued until its work is completed.

I wish to say in regard to the work done by Dr. Moldenke and his committee that the foundrymen cannot understand the work that was necessary to obtain the facts used in preparing this report. The reason that I can appreciate it is that I belong to a similar committee of the American Society of Mechanical Engineers and have done similar work. The doing of this work is no snap and the only compensation is the honor of having done it. The work that has been done will be appreciated in the future, and I hope that it will be appreciated by this Society. If you will investigate the reports of tests made from time to time by Dr. Moldenke and others, you will perhaps get some idea of the work that is being done for the benefit of foundrymen.

Mr. Bell: We would now like to hear from some other member of this committee. Mr. Sterling, what can you tell us?

Mr. Sterling: I do not know that I am in a position to say anything about this as our chairman, Dr. Moldenke, is the only one in Pittsburg that has done any work, but possibly by our next meeting I will be able to say something more. However, as a member of this committee I hope to be able to serve you.

Mr. Bell: Mr. A. W. Walker, let us hear from you.

Mr. Walker: Mr. President, I have nothing to say upon this subject as I know nothing about it.

Mr. Bell: It has been moved and seconded that this report be accepted and that the committee be continued.

Motion carried.

Dr. Moldenke: Mr. President, I have a communication from Mr. Henning, Captain of the German Imperial Artillery, which I would like to read.

Berlin, May 1, 1899.

The foundrymen of Germany send hearty greetings to their American brethren now in convention at Pittsburg. They admire the energetic and effective manner in which science and practice have been made to go hand in hand in the development of the

industry, and confidently expect to hear of still further achievements coming from the free exchange of thought on foundry methods and results at these useful gatherings.

(Signed.) HENNING,
Captain German Imperial Artillery.

Mr. J. S. Seaman, Jr.: Dr. Moldenke has read greetings from the German Foundrymen's Association, and I move that a committee be appointed to return greetings to the German Foundrymen.

Mr. Bell: It is moved and seconded that a committee be appointed to return the greetings of the German Foundrymen's Association.

Motion carried.

Chair appointed Dr. R. G. G. Moldenke as a committee of one.

The Secretary then read an invitation from the Union Trust Company of Pittsburg, to inspect its new bank building and safe deposit vaults at Nos. 335, 337 and 339 Fourth avenue.

Mr. Bell: The Committee on Nominations should now be appointed and I would suggest that the four Local Associations each get together as soon as possible and appoint a member from each Local Foundrymen's Association for this committee and the chair will then appoint one.

Mr. I. W. Frank, Chairman of the Entertainment Committee, here made a statement regarding the trolley ride for the afternoon at which time Schenley and Highland Parks would be visited.

Moved and seconded that the convention stand adjourned until 8 p. m. Carried.

EXCURSION TUESDAY AFTERNOON.

The Entertainment Committee provided cars and those in attendancee upon the convention and a large number of ladies were given a trolley ride, which took them through some very beautiful sections of the city, including a visit to the Carnegie Library, Museum, Art Gallery and Music Hall at East Pittsburg, Schenley Park and Highland Park.

TUESDAY EVENING SESSION.

Mr. Bell: I wish to advise you that the following Committee on Nominations has been appointed:

Western Foundrymen's Association—Mr. W. A. Jones, W. A. Jones Fdy. & Mch. Co., Chicago;

New England Foundrymen's Association—Mr. B. M. Shaw, Walker & Pratt Mfg. Co., Boston, Mass.;

Philadelphia Foundrymen's Association—Mr. Jas. Sterling, Harlan & Hollingsworth Co., Wilmington, Del.;

Pittsburg Foundrymen's Association—Dr. R. G. G. Moldenke, McConway & Torley Co., Pittsburg;

Southern States—Mr. J. P. Golden, Golden Fdy. & Machine Co., Columbus, Ga.

The Committee appointed to wire Mr. Howard Evans then made the following report:

Mr. Sterling: I wish to report that the Committeee have wired Mr. Evans as follows: "American Foundrymen's Association in convention assembled send greetings and sympathy and regret that you cannot be with them and sincerely wish for your speedy recovery." To which we have received the following reply: "Many thanks. Am with you in spirit. May the convention be a howling success. (Signed) Howard Evans."

Moved and seconded that report be accepted and committee discharged from further duty. Motion carried.

Mr. Bell: We will now have the pleasure of listening to a description of "A New England Foundry," by Mr. A. W. Walker, whose remarks will be illustrated with stereopticon views.

Mr. Walker: After the cordial reception we have had to-day, after we have been offered the key of the city and associated familiarly with the chief dignitaries, after we had nearly forgotten that we are foundrymen, and had become convinced that we are business partners of Mr. Carnegie and Mr. Westinghouse, it is rather hard to be reminded that we are pounders of sand and pourers of melted silicon and scrap.

However, it falls to my lot to dispel every pleasant illusion of the day, and to bring you down once more to solid facts.

In one of the addresses of the morning we were told that one of the things Pittsburg is noted for is the manufacture of pickles. Now one of the things my native city is noted for is the manufacture of baked beans.

We usually associate pickles and baked beans, so that there ought to be a bond of union between Pittsburg and Boston. "P" stands for both Pittsburg and *pickles;* and "B" stands for both *beans* and Boston.

It was certainly very thoughtful on the part of the gentlemen who prepared the badge of this convention to attach a bean-pot to it, and I for one am very grateful for this delicate courtesy.

Mr. Walker then proceeded to address the convention, his remarks being illustrated with about 90 stereopticon views showing interior and exterior views of the plant of the Walker & Pratt Mnfg Co., at Watertown, Mass. Following is an abstract of Mr. Walker's remarks:

The buildings described were erected in a part of a tract of some forty acres, which is controlled by the company. The land not required for the manufacturing buildings has been tastefully laid out in streets and house lots for the homes of employees. The factory buildings are of modern one-story construction, admirably lighted and most conveniently arranged for the various processes in the manufacture of stoves and heating apparatus.

The main foundry building, in which the molding is done, is very liberally provided with windows and skylights, the area of glass being more than 35 per cent. as large as the area of floor. A novel feature of these works is the overhead track, or railway; by which suspended from special carriages, heavy loads may be moved. By this overhead track, or "trolley," all the melted iron is distributed about the foundry. This is understood to be very unusual in stove foundries, in which it has been generally supposed that mechanical distribution of melted iron is not practicable. This company has, however, carried out the plan in a highly successful manner.

Mr. Walker described the improved cupola used by the company, and many details of mechanical arrangements and labor-saving devices for handling materials; refinements which have not previously been used in foundries. The cupola-charges of pig iron and fuel are handled on special roller bearing cars of the company's design.

The company has taken an unusual position in providing exceptionally fine lavatories for its workmen. There are three toilet rooms, of which the main one is over a hundred feet long, and thirty-five feet wide. In this room are eighty separate bathing rooms or closets, similar to those used in the best gymnasiums. Each of these eighty small rooms, has hot and cold water faucets and a clothes closet with lock and key. The molders bathe daily before leaving the works, and greatly appreciate the conveniences offered by the company.

The various steps in the production of stoves, furnaces and heating boilers were fully illustrated and described. The method of removing sand from the castings, the polishing and nickel-plating departments, the shops where the various castings are put together to make complete stoves, the large warehouse for finished goods and the buildings for the construction and storage of patterns were all shown and described in turn.

The company has undertaken to make its factory attractive in its surroundings as well as efficient in its methods of manufacture. The grounds about the building have been tastefully laid out under the direction of a landscape architect, and about twelve hundred shrubs and trees have been planted. The company believes that, for the production of the high grade of goods for which it is noted, the health, comfort and even the convenience and taste of its employees must receive due consideration.

Mr. Walker's address received the closest attention. The speaker closed with an invitation to all foundrymen and others interested in advanced shop practice to visit these works and see for themselves the many improvements and new features of manufacture.

The Walker & Pratt Mfg. Co. are well known in New England as manufacturers of the "Crawford" ranges. The new works are located at Union Market Station, which is in the town of Watertown, Mass., near the Watertown Arsenal.

Mr. Bell: The next on the programme will be a paper by Mr. W. J. Keep, entitled "Original Methods of Handling Materials at the Works of the Michigan Stove Co., Detroit, Mich."

Mr. Keep then read the following paper:

ORIGINAL METHODS FOR HANDLING MATERIALS AT THE WORKS OF THE MICHIGAN STOVE COMPANY, AT DETROIT, MICH.

By W. J. KEEP, Superintendent.

One of the results of a series of years of business depression is that those in charge of manufacturing will have time to devote close attention to each department and by improved methods of production partially compensate for decreased sales. With the advent of dull times in 1893, The Michigan Stove Company began to devise new methods for manufacture. Probably the only portion of these improvements that would interest the general founder would be the method of handling material and the management of cupolas.

The space available for storage of flasks, coke, iron and sand is very small, which was for years considered a disadvantage, but under the changed methods it is a positive advantage. Formerly all cupola supplies were wheeled to elevators and were hoisted to the platforms and unloaded, then when the cupolas were charged the materials were placed on scales and weighed and handled again in charging. While using elevators it was necessary to maintain inclined runways to be used in case of frequent derangement of elevators. It was found that wheelers would stop to rest about so often, and invariably would wait at bottom and top of the elevator for one reason or another, therefore when the elevators wore out they were not replaced and it was found cheaper to use the inclined ways exclusively.

All of the melted iron is taken in hand-ladles holding 50 pounds, therefore there is no use for appliances for carrying melted iron. The railroad track on which all supplies are received is located between the iron yard and the foundry, making it necessary for all materials to cross the railroad track in going to the cupolas.

In common with other founders, it had been impossible to have melters charge materials as they reported them, causing

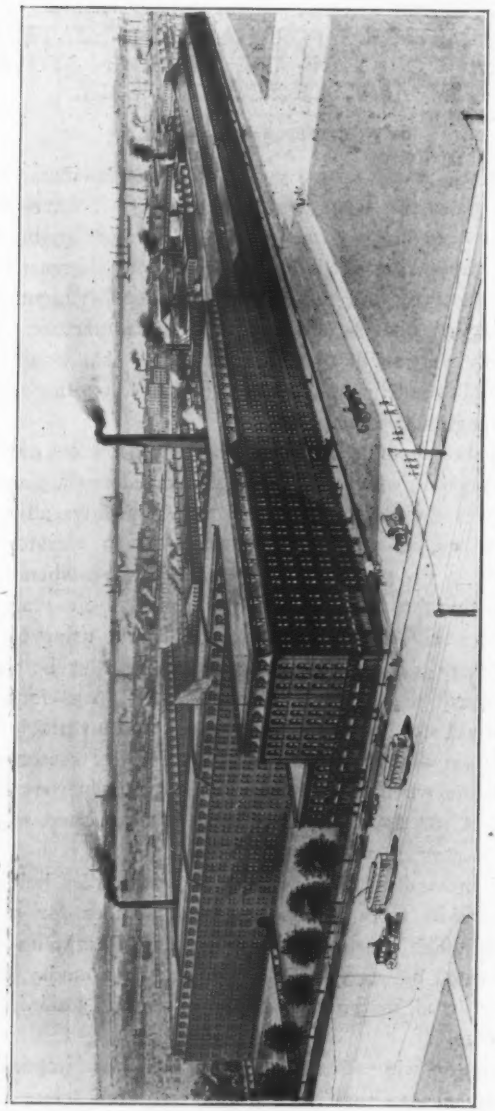


FIG. 1—WORKS OF THE MICHIGAN STOVE COMPANY.

each year a great shortage in both coke and iron when the amount purchased was taken into account, and it was a com-

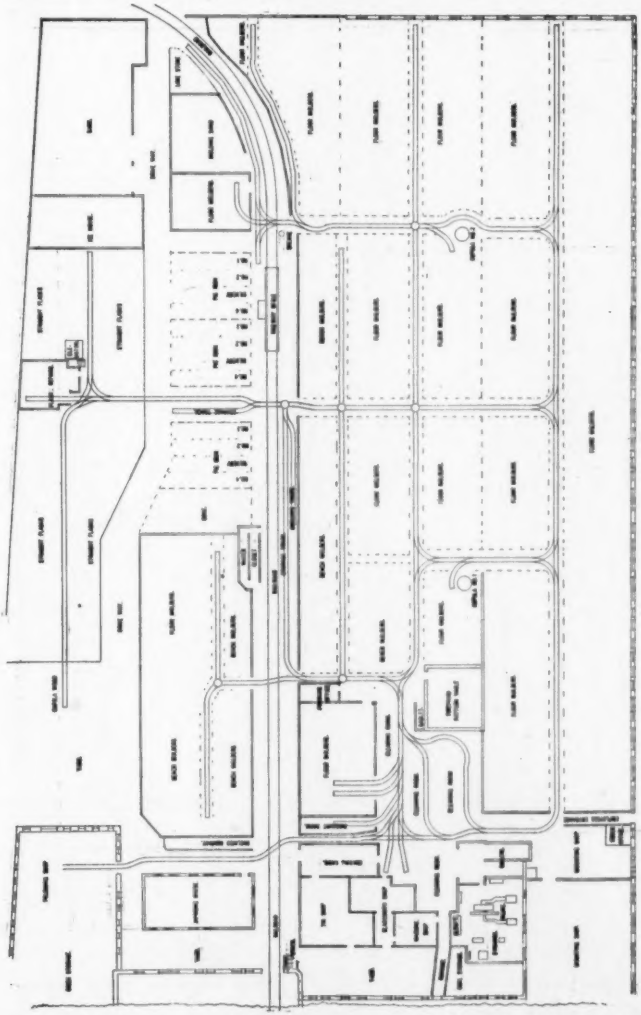


FIG. 2—PLAN OF INDUSTRIAL RAILWAY ON GROUND OF FOUNDRY.

mon experience to show more castings produced than pig iron melted.

Flasks had always been exposed to the weather, and could only be found by men who were familiar with their location, and

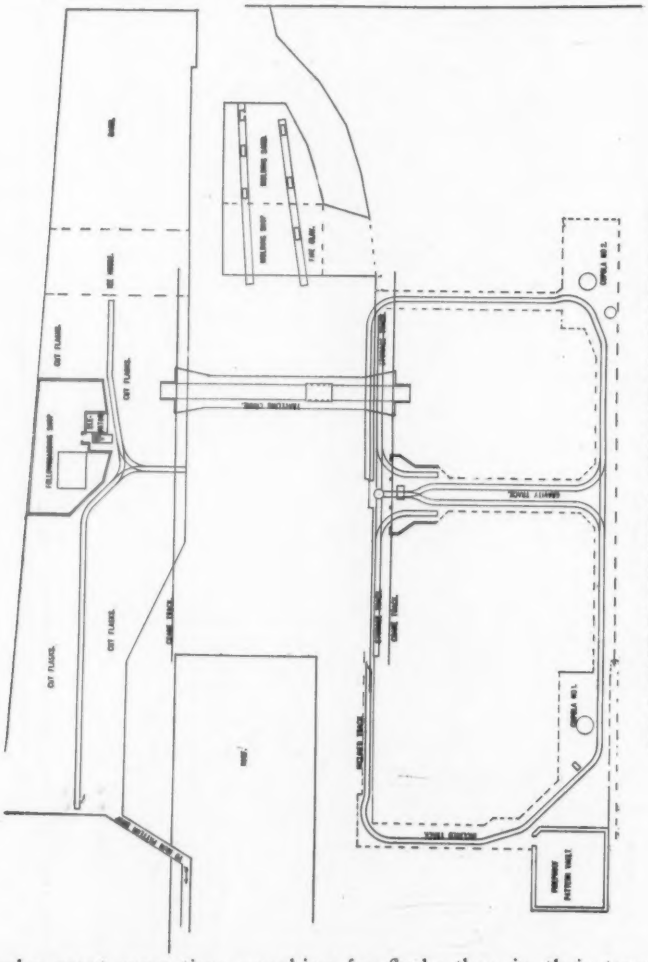


FIG. 3—PLAN OF INDUSTRIAL RAILWAY ON SECOND FLOOR.

who spent more time searching for flasks than in their transportation when found.

The carpenter shop was located a long distance from the

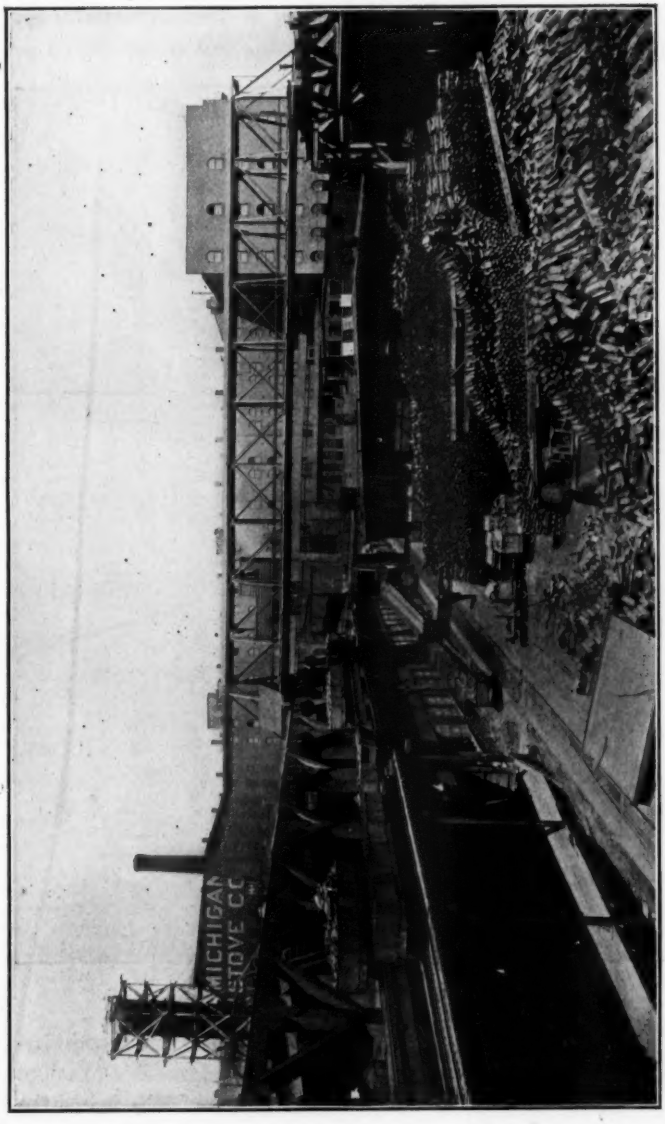


FIG. 4—REAR VIEW OF THE MICHIGAN STOVE COMPANY'S WORKS.

flask yard, requiring that flasks should be wheeled to the shop, and when ready to use should be again wheeled to the foundry.

FIG. 8—FROM ROOF OF FLASK HOUSE UNDER CRANE.

The subject of improvement in methods was under consideration for several years. At one time it seemed possible to adopt a trolley system, but difficulties appeared that finally led to the

adoption of ground tracks with 20½ inch gauge, and curves with a 12 foot radius, and as few turntables as possible, requiring cars with flexible wheel base.

A traveling crane was erected to reach every part of the yard. With it all materials for cupolas were hoisted to a weigh house on the foundry roof and were then sent to the cupolas on a gravity road.

FIG. 6—MAKING UP CHARGES IN WEIGH HOUSE.

A two story building was erected to hold all flasks and the carpenter shop was located in its center, with an elevator reaching the roof and each floor.

Electricity was adopted for motive power. After submitting drawings for the general arrangement to several manufacturers of foundry appliances, it became apparent that many modifications would be necessary as the work progressed.

Contracts were therefore given for the whole of the work to a Detroit firm, the Russel Wheel and Foundry Company, who

had begun the manufacture of industrial railways and cars, and who were willing to design a crane that would suit the requirements.

FIG. 7—CHARGING No. 1 CUPOLA.

Fig. 1 is a general front view of the plant of the Michigan Stove Company.

Fig. 2 is a ground plan of the foundry and buildings containing industrial railway, and shows curves, turntables, crossings of railroad and location of supplies and flask house. All together, there are over three-quarters of a mile of industrial railroad.

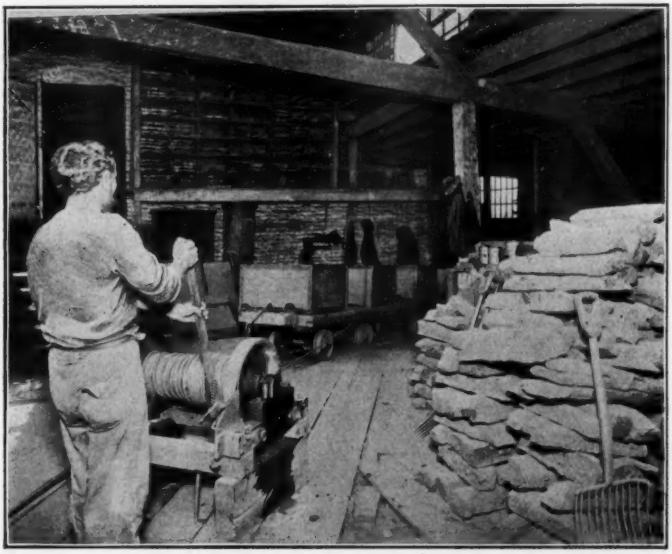


FIG. 8—LOWERING CARS BY FRICTION WINCH.

Fig. 3 shows all tracks located above the ground, and also shows the location of the rails for the crane to travel upon. Flasks from the second story of the flask shed are run on cars to the end of the track, and are taken by the crane to the ground track.

On the roof of the sand shed are tracks for dump cars which drop sand or fire clay into the space beneath.

On the edge of the foundry roof are tracks for storage that curve into the weigh house. On one of these is stored cars, each

of which contain three boxes of coke, and on the other track are stored cars each containing three boxes of sprues.

FIG. 9—UNLOADING MOLDING SAND.

A car with pig iron is lifted from the iron yard to the weigh house, where the exact amount of pig iron is weighed. By a swinging crane and a special lifting device a box of sprues is

transferred to one end of the car and the correct weight put on, then a box containing the required amount of coke is placed on the other end of the car, the whole being one charge for a cupola. The car is then pushed on one of the gravity roads to one of the cupolas, and so on until the tracks between the scale and cupolas are filled with loaded cars. When the contents of the cars are charged into the cupola, the cars from No. 1 cupola are by a friction winch run down the track on the old incline to the yard, but the empty cars from No. 2 cupola are sent by a gravity track to a storage track near the weigh house. The first car each day contains limestone which is dumped on the platform near the cupola and shoveled in with each charge, about forty pounds being used to each ton of iron. After that car is a car of wood for lighting the fire, then three cars of coke for the bed, after this each car contains 1,300 pounds of pig iron mixed as ordered, 700 pounds of sprues and 230 pounds of coke. When the last car containing a charge of iron is unloaded, cars containing iron from the dump and gangway sweepings are charged.

Fig. 4 is a general rear view, showing in the distance a rope drive 400 feet long transmitting 75 horse power. This was formerly exposed to the weather, but gives much better satisfaction since it is covered by a roof. This figure shows a general view of the crane, which is an ordinary bridge, without a floor, provided with lateral trusses to allow the cab which contains the hoisting machinery to run on the lower chords. The bottom of the cab is of plate glass, enabling the operator to see everything in the yard beneath him.

In the cab are three controllers for operating the crane. The length of the crane is ninety feet from one track to the other. Its capacity is three tons, the length of wheel base is fourteen feet, the speed of hoist is 50 feet per minute, of cab 100 feet, and of bridge 130 feet. The motor for hoisting is 6 H. P., that for moving the cab 12 H. P., and for moving the bridge 12 H. P.

The trestles for the bridge are pine, those on the foundry end are a part of the frame of the foundry, and on the other side form the frame of the flask house.

Fig. 5 is a view of the under side of the crane, taken from the roof of the flask house. It shows the cab running on the lower chords of the bridge. It also shows all the bracing of the

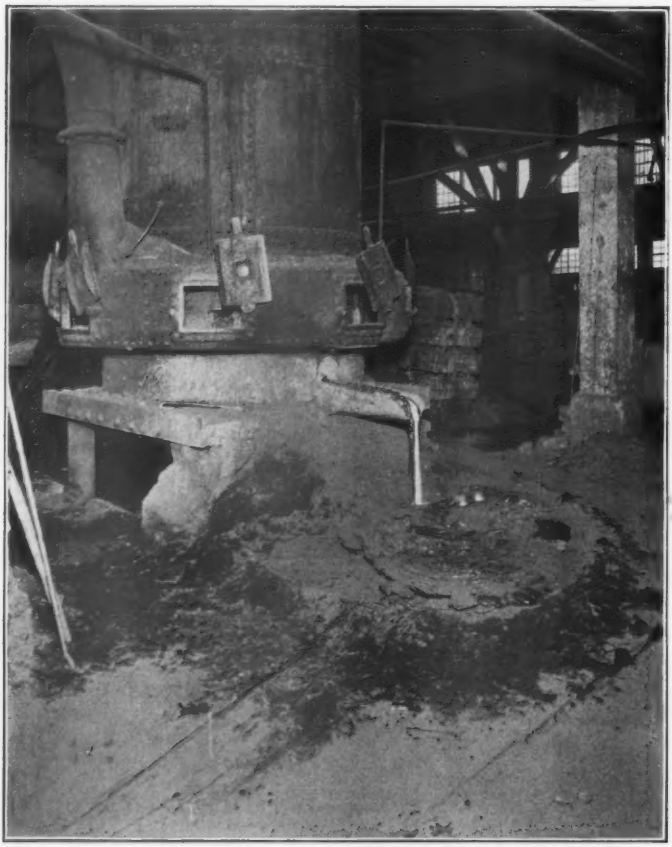


FIG. 10—REMOVING SLAG BEFORE DROPPING BOTTOM.

bridge. A car containing 1,300 pounds of pig iron is being hoisted to the weigh house, which is on the foundry roof, directly in front. On the right of the weigh house is the storage track for coke, which curves into the weigh house, and on the left is

the storage track for sprues. Just in front of this and a little below it is the storage track for empty cars that have been sent out from No. 2 cupola. The crane in returning from a load can take back two empty cars. Beneath this track is the old incline for wheeling to No. 1 cupola, which is now occupied by an inclined track from No. 1 cupola, down which cars are lowered by a friction winch near the cupola. On the ground below this track is a storage track. Below the crane and leading from the entrance to the foundry floor is the track to the flask house, and on the right is a storage track on which is stored cupola cinders and sprues.

Fig. 6 is a view in the weigh house. A car of iron is on the scale. The scale is balanced with an empty car standing on it. The first beam weighs 1,000 pounds, the second beam weighs 355 pounds, the two weighing the 1,300 pounds of pig iron, the 55 being for the sideboards. The next beam is set for 800 pounds, which weighs 700 pounds of sprues, 30 pounds of sand and 70 pounds for the box. The next beam is set for 300 pounds, 230 being coke and 70 pounds the box. The next beam is set at 810 pounds, 600 pounds of coke and 210 pounds for three boxes. The other beam is set at 540 pounds, 400 pounds of coke and 140 pounds for the two boxes. These last two beams are for making up the bed of coke. All beams are in a locked box. The ones needed are pulled out and the load is varied until the beam tips.

The car containing 1,300 pounds of pig iron is brought up by the crane and the weight made correct. A car with boxes of sprues stands on the left curved track, and a car of coke on the right track. The swing crane over the scale lifts a box of sprues and swings it to one end of the car. This crane is fitted with roller bearings and a single motion of a cam lifts the box enough to swing clear of both cars. When the sprues are weighed the crane swings over and gets a box of coke. When the charge is complete a tally peg is moved down one hole on a tally board.

Fig. 7 shows the charging into the cupola. The cars pass the cupola in the position most convenient to the melter. It was at first intended to dump the box of coke and the box of sprues

directly into the cupola, but fearing that the materials would not be distributed uniformly the boxes are dumped on the floor and thrown uniformly over the whole surface with a fork.

FIG. 11—MOLDER MAKING RECORD OF HIS CASTINGS.

In the view a box of coke has already been dumped and shoveled in and the pig iron is being evenly distributed, one man handing it from the car to the man charging. The box of sprues.

is afterwards dumped off the car. When the car is empty it is shoved ahead and another car takes its place.

Fig. 8 shows eight cars being lowered down the incline to the yard by a friction winch. On the right is seen charges of iron weighed out and piled, enough for one day's melt. These are stored on each cupola platform, to be used if anything should get out of order. The sprues and coke and pig iron could be wheeled up the old incline in such a case if it were necessary.

Fig. 9 shows the crane unloading a car of sand. There are three trucks, each having two wheels and a caster. There are three boxes, which will each hold about 1,500 pounds of sand, and which have drop bottoms dumped with a lever. A truck and one of these boxes are run into each end of the car and two men shovel sand into each box. The third truck stands outside the car on the platform, and the crane lowers the third empty box on it just as two men roll a filled box out on the platform. They hook onto the full box and the crane lifts it onto the roof track, while the men roll the empty into the car for another load. The box is loaded onto a car, on the roof, which is run by a man to one of the openings in the roof, where the bottom is dropped and the car brought back. To unload a car of sand with wheelbarrows takes three hours for six men, while six men with the crane will unload it in one and a quarter hours. Fireclay is unloaded in the same way, and is dumped into an overhead bin holding two car loads. This bin has in its bottom a hopper with a slide, through which the ground fireclay falls directly into the kettle where it is mixed for cupola daubing.

Iron trays with trips operated by the man in the cab were arranged to unload iron and coke from cars, but the crane is so occupied with hoisting cars to the weighhouse that iron and coke is unloaded by contract by wheelbarrow. This view shows a man making up a charge of pig iron, taking the required number of pigs from each pile. On the roof is seen the covered exit from No. 2 cupola with empty cars coming out onto the storage track below the storage track for sprues.

Mixing the Pig Iron.—No scrap iron is used, and the mix-

ture is No. 1 soft, No. 2 foundry, No. 4 foundry and a silvery iron varied in proportions to keep the quality uniform. There are three sets of piles containing these four irons. Each grade of pig iron is placed in a pile nine feet wide and fifty feet long. A car can be placed centrally on the top of any one of these three sets of piles and with very few steps the loader can take the required number of pigs of each kind of iron and pile them at the central part of the car.

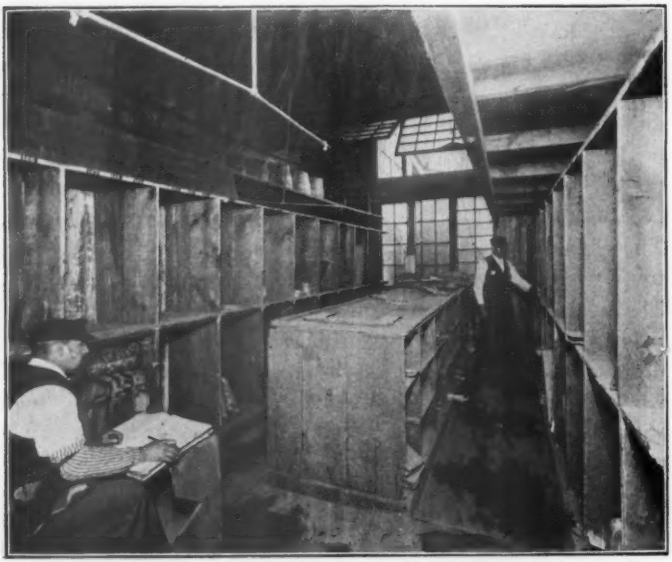


FIG. 12—RECORDING DISCOUNT IN DISCOUNT ROOM.

The product has been more uniform since mixing iron in this way, than when left to the caprice of a melter. The total weight of pig iron and of coke is accurate, and there is, therefore, no discrepancy between weights of material purchased and of castings produced. The remelt is also accurately weighed and the ratio of fuel to iron is accurate. By placing one complete charge on each car and keeping tally with pegs at weigh house and at cupolas no mistakes can be made.

At present we have No. 1 cupola lined to 68 inches and No. 2 cupola lined to 62 inches and both are driven by a single No. 7 Roots blower which has been used eighteen years. This blower when new was rated to melt fourteen tons per hour, but the two cupolas now melt twenty tons per hour with the single blower. We have purchased a new Roots blower of a capacity that will melt thirty tons per hour, which will deliver the iron as fast as the men can carry it away, and will give a continuous stream.

Recovery of Iron From the Cupola Cinders.—When all these devices were in working order it was found that the picking over of the cupola bottom and separating unburned coke and large pieces of iron, and taking cinder to, and running it through the cindermill and back to the weigh house, took more time and power than any other operation connected with the cupolas, and to save this the following plan was adopted: (See Fig. 10.)

After the last iron has been drawn from the cupola at night the breast is knocked in and the slag runs out on the floor, a dam of sand keeping it from spreading. Iron that comes out with the slag forms a thin slab on the ground, which can be separated when cold so that not a particle of iron will be lost.

When the bottom is dropped it is composed of unburned coke, unmelted pigs and small pieces of iron, much of which has run into the coke, and some bits of slag and iron mixed, but nothing is cemented together, because the slag has been drawn off.

In the morning the pieces of sand bottom are picked out. The rest is quickly shoveled into cars and run out on the central yard storage track. The sculls from ladles are thrown into the same cars as there is considerable iron adhering to them. These cars are stored during the day on the central storage track, and follow the car containing the last cupola charge and the contents is dumped on the cupola platform. The chargers have nothing to do for an hour after the last charge is on, and they with forks carelessly shovel to one side unburnt coke, and to another place iron and cinder, and to another place unmelted pigs or iron. The

cinder and small particles of iron and iron from gangway sweepings are thrown on the last charge. Then the fine material that could not be taken up with the fork is riddled and that which is

FIG. 13—CARPENTER SHOP FROM SECOND FLOOR.

retained in the riddle is thrown in the cupola. The pig iron that drops with the bottom must be charged next day with enough unburned coke to melt and the rest of the unburned coke can

be used as the melter chooses. Both iron and coke having been weighed the previous day, should not be weighed again.

Iron borings or other fine scrap can be put on the last charge before any of the cinder is charged. As soon as the cinder is in the cupola, the iron at the tap hole is perceptibly hotter, the cinder being wet acts like the wet covering over a blacksmith's fire, the blast being held down, and every particle of iron and slag are melted out and a cover of hot fine coke is left. The iron and slag are drawn out when the breast is knocked in.

This fine coke is returned each day to the charging door and the melter has quite a quantity to use when he thinks a little extra is needed. This dispenses with all cinder mills, power and repairs, and labor connected with them, and saves all the fine coke and iron that was formerly carted away as mill cinder. It saves every particle of iron from every quarter and prevents material blowing out of the cupola during the last of the heat and lodging on the foundry roof. It costs nothing to sort the bottom after the last charge is on, whereas sorting in the morning must be paid for. In cases where the slag is not drawn from the cupola during the heat, it may be necessary to add, with the last charges, sufficient limestone, oyster shells or fluor spar to make the slag fluid enough to run out of the tap hole.

We also contemplate enlarging the tap hole so that all iron and slag will run out of the same hole, the slag to be skimmed from the iron and conducted through a side spout to a wheelbarrow which will be taken away as fast as it is full.

Fig. 11 is a view of a molders' folding desk. Two other desks are closed. The method of keeping the molders' piece account is peculiar. Each molder has one of these folding desks in which is placed a sheet on which is written the name of each piece that the molder has on his floor, the number he is to make each day, and if it does not run steady the total number to be made. When a molder has shaken out his work he makes separate piles of each kind of castings and marks with chalk on the top of each pile the number of perfect castings. He also marks on his slip the same number. In the morning the castings are

wheeled to the cleaning room by contract and a clerk goes down each gangway immediately ahead of the wheelers and compares

FIG. 14—MACHINE FOR REMOVING NAILS FROM BARS.

the numbers on the slip and on the pile and counts each piece and examines closely enough to see if the piece is recorded correctly. He then carries with him the slip, which, when he has

collected a sufficient number, he sends to the time keepers' office, when the account is transferred to the regular books. This is completed about 10 a. m., when the books and slips are taken to

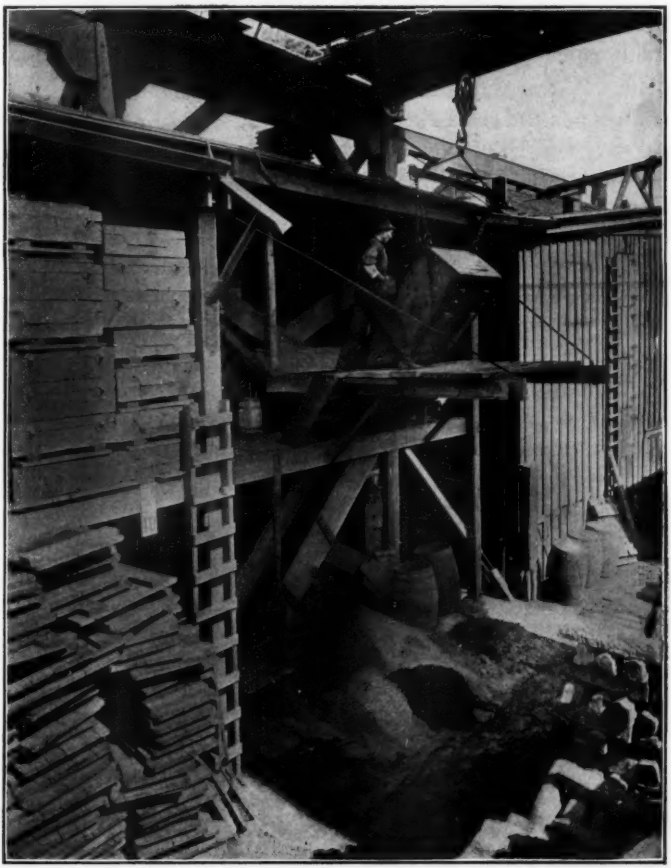


FIG. 15—SCREENING SWEEPINGS FROM GANGWAQS.

the discount room, and all discount is entered by marks on the slips and also on the book. (Fig. 12 shows a part of the discount room.) The slips are then placed again in the molder's desk,

when he can see what discount he has, and from 12 to 2 can inspect it, but cannot take it from the room. If there is any piece that can be made good or should not have been discounted the molder can place it on a table and call the foreman's attention, who can allow it to be fixed. Each molder is furnished with a stamp containing his check number, with which he stamps each mold. In this way each casting contains the molder's number and no mistake can be made in discounting. In figuring up a pay the molder's account is figured separately on the slip and on the book, which checks all operations, and there are never any disputes regarding mistakes in counts. The molder knows exactly what he is earning each day.

On each side of the discount room are bins, each holding the discount of three floor molders. At the center of the room are smaller bins holding the work of three snap molders. This discount is loaded on cars at 2 p. m. and taken to the weigh house.

Fig. 13 is a view of the carpenter shop. The upper floor is used for follow boarding, and making new flasks. The motor is a little to the left. The foreman's bench is just in front where he can see all that is going on. Below on the first floor is a band saw and men are rebarring flasks.

Fig. 14 is a view of a machine for pulling nails. It will pull 75 nails a minute. On the other end of this machine is a trip-hammer, under which the nails are placed to be straightened. It costs to pull, brighten in a tumbler, straighten and assort nails 50c per keg, and they are as good for the molders as new nails. All nails are taken from old bars and the bars are then used over again, making a great saving in nails and lumber. On the lower floor are stored all straight flasks and the bars are changed to fit different jobs. On the second floor are kept all cut flasks, those for each stove being piled together.

Fig. 15 shows a screen with the crane dumping a carload of sweepings from the foundry gangways. The sand falls through and is removed by a cart, while the iron runs into the box at the lower end of the screen. As soon as the sweepings are all dumped the crane lowers the box to get the iron, which is taken to the weigh house.

Fig. 16 shows a winch for moving steam cars on the main railroad track. At the other end of the track is a sheave around which runs a $\frac{5}{8}$" steel wire cable, each end of which is wound around one of the drums of the winch. One of the drums runs at twice the speed of the other, and one drum is free to unwind as the other winds the cable. At one point in the cable there is a

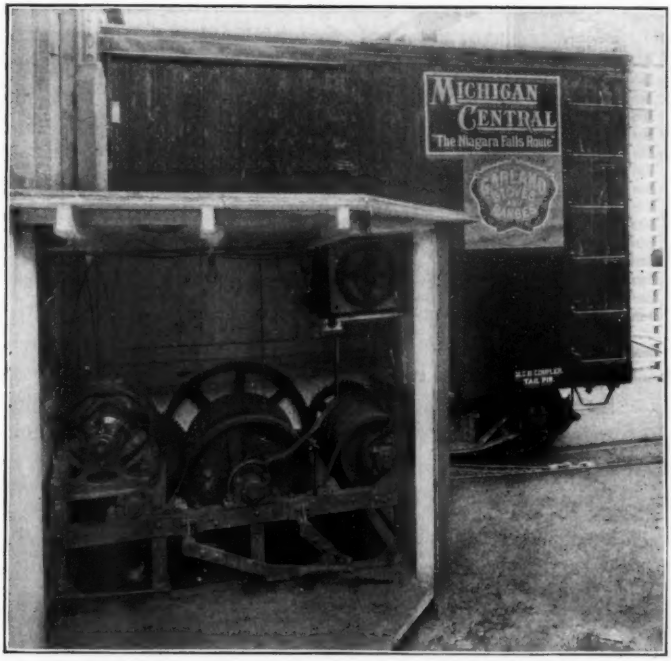


FIG. 16—ELECTRIC WINCH FOR MOVING RAILROAD CARS.

link into which is hooked the end of a chain, the other end of which is attached to a car. An electric signal tells which rope to wind and when to stop. The motor of the winch is 8 horsepower and will move on the straight track several cars. It takes one man at the coupling and one man at the winch to move a car or to make up a train. This same winch will be used at a future time to run some kind of coal conveyer to a receiving bin over the

boilers, which are already fitted with Murphy smokeless furnaces, and have hoppers for self feeding from this storage bin, but thus far no satisfactory conveyor has been found.

Having electricity, all parts of the works are lighted, saving over $50 each month during a good part of the year in gas bills.

The cost of the apparatus described was about $16,000, which included electric generators and the flask building.

We were not able to unload material from steam cars as we had calculated and the sixty cars which were purchased were all needed in handling cupola material and flasks. Therefore the tracks and cars have not been used to take castings from the foundry to the cleaning room, and for this reason one-half of the tracks are not yet used. We expect to construct a cross between a car and a wheelbarrow by which one man can take half a ton or a ton of plate on the tracks to the cleaning room as quickly as he can now wheel 500 pounds, in which case he would expect to do such work at night, so as to have all gangways cleared and cleaning mills loaded at night. For various reasons we have not saved half the labor that we anticipated, and we expect to do much better in time. As it is, the saving is such that after setting aside $1,000 each year for interest on the investment, we shall pay for the whole investment in three years with the present saving.

Moved and seconded that a vote of thanks be tendered to Mr. Walker and Mr. Keep for the entertainment of the evening.

Motion carried.

Moved and seconded that the convention stand adjourned until 10 a. m. Wednesday morning.

Motion carried.

Adjournment.

WEDNESDAY MORNING SESSION, MAY 17TH.

The meeting was called to order by President Bell at 10:30 o'clock. Secretary Penton read a telegram from Prof. A. W. Smith, of Cleveland, stating that he would be unable to be present before noon.

Mr. Bell: In place of the paper by Prof. Smith, we will listen to the report of the Committee on the Standardized Drillings, of which Mr. Thos. D. West is the chairman.

AMERICAN FOUNDRYMEN'S ASSOCIATION'S STANDARDIZING BUREAU.

COMMITTEE'S PROGRESS REPORT.

At the last convention, Cincinnati, June, 1898, a committee was appointed for the purpose of establishing a central agency for the distribution of standardized drillings. This committee found its origin through the interest of the Pittsburg Foundrymen's Association in a paper read before that body April 25, 1898, and published in the American Foundrymen's Association Journal of May, 1898, showing the need of greater uniformity in analyses, and suggesting, in outline, plans for originating a central standardizing agency. It was a reform of which but few realized the importance and the obstacles to be overcome before the same could be established. Before proceeding to outline the committee's progress in this work, it will be well to describe what standardized drillings are and for what they are used, also to illustrate the methods pursued to accomplish the object sought.

In brief, standardized drillings are especially prepared and carefully analyzed samples of iron, by which the chemist can test the accuracy of his work.

Almost every trade possesses some means by which its artisans can tell whether their labors have been productive in obtaining the perfection desired. The appearance of the finished casting indicates to the furnaceman or founder the results obtained from his iron. A trial of a machine or engine shows the machinist or engineer the perfection he has attained, but the completion of an analysis by a chemist presents no tangible evidence of the accuracy of his results. The only way a chemist can know the correctness of his results or give others assurance that his work is right is by having them checked or by analyzing drillings that have been determined by competing chemists, to find whether results agree. The latter process is, in a sense, a method of checking similar to the use of standard weights to test the accuracy of scales. No laboratory is com-

piete without its standards any more than a furnace or foundry would be without standard weights for occasional test of scales.

The necessity for a laboratory having something in the way of standardized drillings has led many heretofore to make their own. This has generally been done after the following plan: The chemist, having decided upon the grade of iron thought best for the work, sought out a piece of clean pig metal of such grade, and drilled it until he had obtained from eight to twelve pounds of drillings. These would be well mixed and in some cases, ground in a mortar to make them sufficiently fine to pass through a ten, twenty or forty-mesh sieve. This done, he would put up packages of a few ounces each and mail them to other chemists with a request that they analyze them for metalloids for which he wished to obtain standards. When the different results had been reported, he would accept the average as his standard for the drillings in his possession, and which were generally preserved by tightly sealing in a bottle, labeled with the analysis, and kept on hand for use at any time.

These standardized drillings, being accepted as containing certain percentages of carbon, silicon, sulphur, manganese or phosphorus, could be reanalyzed at any time to check the chemist's own or others' work. An observing person, having an opportunity to visit laboratories, could often find the chemist using these standards to check chemical, or some short-cut method which he or some other chemist had devised. Then again, they might be used as checks when the correctness of results had been questioned. In reanalyzing a standard, should a different result be obtained, the chemist was naturally left to conclude that some of his chemicals, methods or work was at fault.

The process by which the individual chemists obtained their own standards was, as a rule, long and tedious. It often took from four to six months to get in all the results. Then again, as a rule, the results varied so much that the average accepted would at times seem more like guess work than anything coming from accurate work and methods. The variation in analyses

thus obtained have often caused great differences in standards in use in different circles and perplex managers of furnaces, steel works, foundries and chemists, rather than help to correct evils and prevent losses.

It was the opportunity of observing the practice of blast furnace chemists in obtaining their standards which led to the idea of one central agency from which all could obtain standardized drillings which had been determined by a few of our best known chemists.

The first work of our committee was to adopt and perfect plans to achieve the end sought. This was done practically upon the lines suggested in the paper read before the Pittsburg Foundrymen's Association, April, 1898, and which secured for us the able services of Prof. C. H. Benjamin to supervise the work of making drillings from cylindrical castings, and that of Prof. A. W. Smith (both of Case School of Applied Science) to carry forward the work of preparing, standardizing and packing the samples. We were also fortunate to secure and combine the services of Messrs. Booth, Garrett & Blair, Andrew S. McCreath, Cremer & Bicknell and Prof. A. W. Smith to analyze the drillings, the average of which results were accepted as standards.

The greatest obstacle in the way of establishing and maintaining a central standardizing agency lay in the difficulty of obtaining a sufficient amount of uniform turnings or drillings from one sample of iron, free of sand, grit, slag, etc., to permit all laboratories to obtain a pound or more of them. As a rule, chemists have found it difficult to obtain 25 pounds of clean, uniform and reliable samples.

A study of this phase of the subject will show that the practicability of establishing and maintaining a central standardizing bureau is largely dependent upon the ability of the founder to make large castings, weighing 500 pounds or more, from which could be obtained a large amount of clean, uniform drillings. For this reason a well-known writer has aptly said that the establishing and maintaining of a central standardizing agency

is properly foundrymen's work. As the making of these castings involves principles of founding interesting to many, we illustrate the plan used, which is as follows: A mold of dry sand for the outer body and a dried core for the inner are made as seen in the plan and section view of Figs. 1 and 3. The construction of the mold explains itself. The secret of getting a clean, solid casting lies mainly in the method of gating and pouring it. At A is a gate leading down to the bottom of the mold at an inlet at D. The round gates B, seen at the top of the mold, are placed about 4 inches apart and are ½ inch diameter. A riser is seen at E. In starting to pour the mold, the molten metal is directed to drop from the ladle into the basin at the point marked W in a way that will allow it to flow gently down the gate A and enter the mold at D to prevent the bottom being cut by the top gates. When from 30 to 50 pounds of metal has entered the mold, a quick turn of the ladle empties a large body of the metal into the pouring basin, quickly filling all the gates at B; this then drops the metal down upon that which is rising from the stream flowing in at D. This action is kept up until the mold is filled and the metal runs out at the riser E. After this point is attained, the pouring is slackened and a steady stream maintained until from 300 to 500 pounds of metal has flown through the riser E to run down the incline seen at S into the scrap hole X. The effect of allowing such a large body of metal to flow through the mold by making it enter the gate at A is to keep up an agitation after the mold has been filled, which in turn will be most beneficial in causing the metal in the mold to mix well and counteract variations in structure that might otherwise take place. The metal dropping from the top gates B causes a disintegrating action, cutting into a fine dust any dirt that might accumulate upon the surface of the rising metal, and which, were it not thus chopped up, as it were, into fine particles, would gather in large lumps, and be caught and held fast in the mold walls, with the result that dirt spots, etc., would be found in the mold when the skin was removed by a drill, lathe or planer. Again, the fact that the metal

drops from the top of the mold besides entering at the bottom, causes the top body of the rising metal to be as fluid as that at the bottom, which is also beneficial in causing all scum and dirt to float upward with the metal to the top of the mold or "riser head." Where metal fills a mold all from the bottom, it becomes rapidly duller in rising to fill the mold, an evil which will be readily seen.

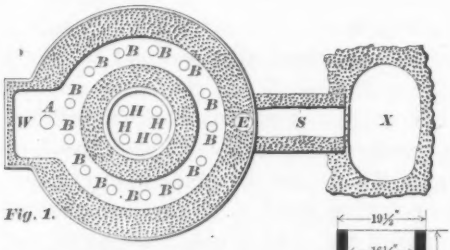


Fig. 1.

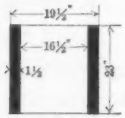


Fig. 2.

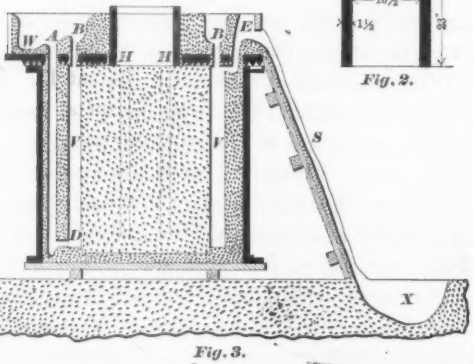


Fig. 3.

Fig. ½ shows a section of the casting obtained from the mold, with the exception of four lugs cast on to assist in holding the cylinder or casting in the lathe while it is being turned. It is to be remembered that these castings had not only to be perfectly clean and sound, but that they had to differ in containing certain percentages of silicon, sulphur, phosphorus and manganese. Some difficulty was experienced and time lost in securing irons that would give the different percentages of

metalloids desired in the casting. Then again, when these metals were obtained, special provision had to be made to melt them properly, which was done very satisfactorily by a little cupola being fitted up especially for the work.

It will be well, at this point, to state also that there is no difficulty in obtaining castings running into tons which might serve for standardizing purposes, if cast upon the principles herein described.

Before starting to make these castings, investigations were made as to the variations in metalloids most likely to be demanded by the trade in general. It was found that samples, high, medium and low in silicon, sulphur, manganese and phosphorus would satisfy most of our country's laboratories as far as iron standards were concerned. To obtain this variety of standards called for the making of three distinct castings of different grades of iron. These were cast at the Thos. D. West Foundry Co., upon the plan herein described and proved excellent for the work intended.

To obtain the turnings or drillings, which had to be fine enough to pass a 20-mesh sieve, was no easy matter and rather a costly affair. To get one pound of drillings per hour was thought to be good work.

The plan of securing these turnings or drillings was first to take off about $\frac{1}{8}''$ from the surface of the casting. These first turnings were cast aside as they contained more or less scale and dirt formed on the surface of the casting by the fusing action of the molten metal upon the sand forming the face of the mold. After this surface has been turned off, and all debris removed carefully from the lathe, the cylinder is turned until about $\frac{1}{4}''$ thickness of the inner shell remains. The turnings obtained from the body after the $\frac{1}{8}''$ thickness is removed from the surface are the ones taken for standardizing purposes. It should be stated that about $\frac{1}{2}''$ thickness at the bottom and the "riser head" of two inches at the top are not disturbed, so as not to have the scale on the bottom of the casting or any dirt that would be collected at the top end mixed with the turnings obtained from the inner body of the casting.

After the turnings had been thus obtained, they were passed through a 20 and 40-mesh sieve. This done, the drillings were then spread out on a large carbonized cloth and thoroughly mixed. The mixing having been perfected, bottles, holding one-third pound, were placed in convenient position and filled with the drillings by having a scoop holding sufficient drillings to give each bottle an equal portion from every filling of the scoop. In filling the scoop drillings are taken from different parts of the spread so that all bottles will contain some of every portion of the drillings. Repeated analyses of different bottles have proved the mixing to be all that could be desired. These bottles were packed in paper cases made expressly for the work. There are two sizes of cases, one holding three bottles, or one pound of drillings, the other holding four bottles, or one and one-third pound of drillings. To allow all a chance to observe the form and manner of packing these drillings and the character of their finish, as being distributed to the trade, the illustration on page 213 is shown.

The standardized samples now ready for distribution cover the following determinations:

Silicon, one each of a low, medium and high range of cast iron.

Sulphur, one each of a low, medium and high range of cast iron.

Manganese, one each of a low, medium and high range of cast iron.

Phosphorus, one each of a low, medium and high range of cast iron.

Total carbon, one determination.

Graphite, one determination.

Titanium, three determinations.

In all, 17 determinations made on four (4) samples.

The samples are designated as A, B, C and D. Sample A, which has been ground to pass a 40-mesh sieve, gives one total carbon and one graphite. Sample B gives a low silicon, a medium sulphur, a low manganese, a phosphorus which is within

the Bessemer limit, and a titanium. This has been passed through a 20-mesh sieve. Sample C gives a medium silicon,

high sulphur, medium manganese, medium phosphorus and a titanium. This has also passed a 20-mesh sieve. Sample D gives a high silicon, low sulphur, high manganese, high phos-

phorus, and a titanium, and has passed through a 40-mesh sieve.

The standards are sold at the price of $5.00 per pound, and in no instance will less than one pound be sold. The samples are packed in bottles, holding one-third of a pound and delivered in cases, as illustrated, holding three or four bottles according to the desires of a subscriber. One bottle each of samples A, B, C, and D, can be had, or a subscriber can have three or four bottles of all one sample (excepting the sample A, which contains the total carbon and graphite, and of which only one bottle will go to any one subscriber); or two or three bottles of one sample and one of another; in fact, bottles of samples B, C and D can be sent in any proportion desired, as it is the wish of the committee to follow the desires of all purchasers, as far as it is in their power. One pound of the samples should furnish enough material for 36 complete analyses, or at least 200 separate determinations. The exact analyses of the samples A, B, C and D will be sent separately by mail, so that they may be placed upon bottles or kept private, as desired by the subscriber.

The amount asked for these standards, considering their cost, is very low, and the drillings such that no chemist could manufacture them for himself at many times the price. The outlay for preparing the four samples was somewhat over $450.00. Moreover, the good that subscribers can accomplish in assisting to promote greater uniformity in the work of laboratories, which have to deal with cast iron, is such that no matter to what part of the country any portion of the sample may be sent, like reports of analyses can be expected at the hands of careful chemists, who are only too often compelled to resort to short-cut methods in order to keep up with the work of their laboratories.

Since the committee received its appointment not an hour has been lost in pushing the work forward to its present state of advancement. It took until the close of 1898 to get the samples ready for distribution. Although it is but little more than four months since the drillings were ready for distribution, we have, up to May 7, 1899, placed the Association's standards in 83 laboratories.

Before giving the names of the concerns using the standardized drillings, the committee wishes here to express their sincere thanks to the trade papers, who have, from time to time, published reports of progress in this work, which has greatly assisted in introducing the standards.

BLAST FURNACES.

Ashland Coal, Iron & R. R. Co.
Pickands, Mather & Co.
Monongahela Furnaces.
M. A. Hanna & Co.
Sharpsville Furnace Co.
Spearman Iron Co.
Mabel Furnace Co.
Stewart Iron Co.
Brier Hill Iron & Coal Co.
Andrew Brothers Co.
Girard Iron Co.
Longdale Iron Co.
Everett Furnace Co.
Warwick Iron Co.
Embreville Iron Co.
Tennessee Coal, Iron & Railway Co.
Hamilton Blast Furnace Co.
R. Heckscher & Sons.
Dora Furnace Co.
McNair & DeCamp Co.
Allegheny Iron Co.
Northwestern Iron Co.
Iroquois Iron Co.
Tonawanda Iron & Steel Co.
Elk Rapids Iron Co.
Ohio Iron & Steel Co.
Penn Iron & Coal Co.
Thomas Iron Co.
New River Mineral Co.
Emma Furnace.
Colonial Iron Co.

STEEL AND IRON WORKS.

Illinois Steel Co.
Kittanning Iron & Steel Co.
Sharon Iron Works.
Youngstown Steel Co.
Bethlehem Iron Co.
Pennsylvania Steel Co.
Ashland Steel Co.
Carnegie Steel Co.
Clinton Iron & Steel Co.
Sloss Iron & Steel Co.
Atlanta Iron & Steel Co.
Watt Iron & Steel Co.
Reading Iron Co.
Martin Iron & Steel Co.

COLLEGES.

Harvard College.
Wooster Polytechnical Institute.
Lehigh University.
Columbia University.
University of Pennsylvania.
University of Michigan.
Massachusetts Ins. of Technology.
Ohio State University.
Yale University.
Michigan School of Mines.
Havemyer University.
Webster University.
University of Minnesota.
Fort Wayne High School Lab.

PRIVATE LABORATORIES.

Rome Testing Laboratory.
Walter M. Sanders.
Enrique Tonseda.
Durant Woodman.

C. E. Linebarger.
R. C. Hindley.
Ludw. Loewe & Co., Berlin.
Edward J. Wheeler.
William J. McGavok.
Dickman & McKenzie.
F. A. Emmerton.
Mariner Hoskins.
J. Blodget Britton & Co.

IRON FOUNDRIES.

Frank-Kneeland Machine Co.
Pittsburg Locomotive & Car Wks.
McConway & Torley Co.
J. I. Case T. M. Co.
Syracuse Chilled Plow Co.
Gates Iron Works.
Sargent Co.
Draper Co.
Builders' Iron Foundry Co.
Snow Steam Pump Co.
William Cramp & Sons.

An encouraging part of this work is the appreciation many exhibit of the advance the American Foundrymen's Association has made in establishing a central bureau for the distribution of standardized drillings as may be seen by letters here on file for your inspection and from which testimonials we quote the following extracts:

"Your plan to systematize this useful work and to carry it out on a larger scale appeals strongly to me, and it is to be hoped that the outcome may be fruitful in benefit both to the makers and to the users of iron.

THEODORE WM. RICHARDS,
Chemical Laboratory of Harvard College."

"Permit me to express my belief that this work of your association of distributing carefully analyzed samples of pig iron is of great value to the metallurgists and chemists of this country.

H. L. MILLS,
Professor Analytical Chemistry,
Sheffield Scientific School of Yale University."

"I believe that every technical school should have a full line of your samples always in stock.

N. W. LORD,
Professor of Metallurgy and Mineralogy,
Ohio State University."

"I have noticed with pleasure your praiseworthy efforts to establish uniformity in pig iron analysis * * * Thanking you for your endeavors to mitigate the perplexities of both the furnace manager and the chemist,

JOHN P. MARSHALL,
Supt. Missouri Furnace, Carondelet."

"I think the method of selling standardized iron samples from a central laboratory, such as the Standardizing Bureau of the American Foundrymen's Association, is one to be commended. The confidence I have in my work after checking with these drillings is very gratifying.

WALTER M. SAUNDERS,
Analytical and Consulting Chemist,
Providence, R. I."

"Yours of the 27th inst. received, and having been referred to our chemist and engineer of tests, he makes the following report: 'In reference to the A. F. A. standards, would say I am pleased with them and take pleasure in indorsing them.'

WILSON MILLER,
President Pittsburg Loco. & Car Wks.,
Pittsburg, Pa."

"We take pleasure in this opportunity to give you a word of encouragement. Trusting you will be successful in interesting all users and makers of pig iron.

R. HECKSCHER & SONS,
Swedeland, Pa."

"We take pleasure in saying that our chemist states he has used the standardized drillings in standardizing solutions and found them to be very exact; and adds that too much praise cannot be accorded the standardized drillings you recently sent us.

ELK RAPIDS IRON CO.,
H. B. Lewis, Pres."

"It is no little comfort to have the standardized samples and to know that the work of our laboratory is correct and reliable.

EDGAR S. COOK,
Pres. Warwick Iron Co., Pottstown, Pa."

"We are pleased with samples. They will, without doubt, greatly promote increasing accuracy in methods of iron analyses.

J. BLODGET BRITTON CO.,
Warrentown, Va."

"We are using standardized drillings for standardizing solutions of sulphur and phosphorus, also for checking other determinations of silicon, graphite, carbon and manganese, and find them very useful in our laboratory. We think it very necessary that laboratories should be supplied with standardized drillings, especially those working on blast furnace products.

L. C. PHIPPS,
Second Vice-President, Carnegie Steel Co., Pittsburg, Pa."

"We are entirely in sympathy with the efforts of your committee, which has our heartiest commendation. * * * We fully appreciate the value of the results which are sure to follow your work, and are very glad to avail ourselves thereof.

J. C. DAVIS,
Supt. The Sargent Co., Chicago, Ill."

"The thanks of all users of iron and employers of chemists are due your committee.

FRANK—KNEELAND MACHINE CO.,
Isaac W. Frank, Pres. and Genl. Mngr."

"The standard samples are a grand idea and the confidence they impart is worth ten times the cost. W. G. SCOTT."

"We do not see how any firm can afford to do without them as they are worth many times their cost.

SYRACUSE CHILLED PLOW CO.,
W .W. Wiard, Asst. Sec."

"We are in hearty sympathy with the objects of the committee, and believe that only good will result to manufacturer and consumer alike. FRANK TENNEY,
Asst. Supt. Penn. Steel Co., Shelton, Pa."

"It is the greatest move for improvement in many years.
ERASTUS C. WHEELER."

"We have checked our routine laboratory work from time to time since receipt of drillings and have found them to be of inestimable value to us.

KITTANING IRON & STEEL MNFG. CO.,
W. L. Scott, Chemist."

"The opportunity which your association offers to obtain in quantity uniform iron samples of definite character, and with statements of the results obtained by experienced analysts must, I am sure, be welcome to every teacher.

H. P. TALCOTT,
Mass. Institute of Technology."

"In connection with the use of the standardized drillings, I wish to say that I believe the plan will result in attaining greater accuracy, will inspire confidence and will enhance the value of analytical chemical work in connection with foundry practice.

W. P. RICKELLS,
Columbia University."

"I am in most hearty accord with the aims and purposes of the American Foundrymen's Association, and believe its aims worthy of support and confidence.

PROF. EDGAR F. SMITH,
Director Laboratory, University of Pennsylvania."

"I very cheerfully say that your idea of having standardized drillings through which to secure greater accuracy from furnace chemists everywhere is entirely admirable.

J. R. JOHNSON, Mngr.,
Longdale Iron Co."

"It has always been a task to get standards, especially standards that would check up with those from different concerns. It will simplify matters considerably if chemists will use standards from one party of the same value, as I have found that most of the errors in sulphur and phosphorus come from different chemist's standards not checking.

J. O. MATHERSON, Chemist,
Ashland Coal Iron & Railway Co."

While it would appear from the above testimonials that this work had been received with favor by those interested in laboratory work, there remains another side of the venture that calls for consideration, and which, to the American, is: Will it pay? To answer this question we append herewith the following statement, showing the total cost of manufacture of the four standardized samples with account of moneys received and stock on hand up to May 8th, 1899.

MANUFACTURING AND FINANCIAL ACCOUNT.

Total expenses to date	$458.89
Collections for drillings to date	370.23
Bills receivable	28.32
Bills Payable	93.56
Cash in bank	4.70
Amount of Standardized Drillings on hand	283 lbs.

Respectfully submitted,

THOS. D. WEST, Chairman, Sharpsville, Pa.
DR. RICHARD MOLDENKE, Pittsburg, Pa.
JAMES SCOTT, Lucy Furnace, Pittsburg, Pa.
P. W. GATES, Gates Iron Works, Chicago, Ill.
E. H. PUTNAM, Detroit, Mich.

DISCUSSION.

Dr. Moldenke: From this report as read you will see that these drillings are being accepted by all the leading foundries and the principal colleges of the country, and I think that the thanks of the Association are especially due to Mr. West.

Mr. Fred W. Bauer: This committee has certainly rendered valuable services during the past year, and this report shows that an immense amount of labor must have been done to accomplish the results which they have presented for our consideration. But there is yet one desirable feature which might be taken up by this Association, and if it can be successfully brought to a finish will add credit to the proceedings of this convention. I refer to the establishment of standard methods for the analysis of iron. A committee was appointed some years ago by the American Chemical Society, but for some reason the work was never completed, and as our society has shown such an interest in the matter, and the committee has worked with such zeal, I think it would be fitting to also take up this matter. Therefore, Mr. President, I move the continuation of this committee with instructions to confer with a committee from the American Chemical Society to establish standard methods for analysis of iron.

Moved, seconded and carried.

Dr. Moldenke: I believe that this committee would like an auditing committee to go through its books.

Mr. West: As chairman of this committee, I would be very glad indeed to have a committee appointed to audit these books, as I have had the matter on my hands and would like to have the accounts audited.

Mr. Bell: I think the best way would be to refer this to the Executive Board, who will take such action as necessary. I also think it would be well to have a meeting of the Executive Board at the adjournment of this session.

Mr. Groves: Mr. President, I therefore move that this matter be referred to the Executive Board of this Association.

Seconded and carried.

Mr. Bell: The next paper we will listen to will be "The History and Technics of Bronze Founding," by Mr. James Powell.

THE HISTORY AND TECHNICS OF BRONZE FOUNDING.

BY JAMES POWELL, President of the Wm. Powell Co., Cincinnati, O.

At the request of your worthy secretary, I rashly consented to prepare a paper for this Convention, upon the history of bronze founding. It was rash on my part, because once that subject is opened up by the conscientious investigator, an avenue of research is revealed which extends back to the period of primeval man until it is lost in the labyrinth of pre-historic ages.

In tracing the genesis of bronze art, I have availed myself of valued references from the magnificent work of Drury Fortnum, whose private collection of bronzes is unrivaled.

Writers of ancient history often refer to the "Bronze Age" as though bounds might be set to the time when bronze or its namesake, "brass," first came to be known as an article of use or manufacture. But if we attempt to fix such a time, we will be surprised to discover that though the "Stone Age" dawns at that remote period when man first began to fashion rudely, his implements of stone, the most diligent antiquarians have hitherto failed to establish just when the "Stone Age" waned and the "Bronze Age" began to develop. Its birthplace was in the Orient, but the time of its origin is veiled in the mists of obscurity, but its advent marked an epoch in man's existence. He groped in ignorance and superstitious fear. "Bronze," as it were, reflected the first glimmerings of an awakened enlightenment, and henceforth man was to enter upon a new existence, for now "Bronze" was to accompany him and become an important aid in his advance to higher planes in civilization—for the story of bronze is the story of man, as he advanced step by step, so the use and art of "bronze manufacture" kept pace with his upward progress. It was the "art preservative of art," for on it depended and from it sprang into existence all other arts and industries.

The absence of the knowledge of iron or steel, so indispensable to our modern civilization, elevated "bronze" to prominence

and value, for though iron is mentioned in the literature of ancient classics, it was so scarce as to be jealously guarded, when possessed at all, and was used as a precious ornament or a cutting tool of superior hardness to bronze. Of the early history of iron, there is none. It has been conjectured that the little of the metal that was known, was of meteoric origin, from the fact that the analysis of ancient specimens of iron almost invariably shows a considerable proportion of nickel, and similar to that of cosmic source.

It is to the existence and knowledge of bronze, therefore, that man was enabled to emerge from a long night of primeval darkness, and with his Bronze Axe, pierce his way through the jungles of ignorance, to the light and liberty of a better life. Once entered upon, the development of the art seems to have been rapid, for researches fail to exhibit very wide differences in the quality of material or workmanship of the early bronzes.

The axe, chisel and hammer were doubtless the first development, supplemented by the fabrication of warlike implements.

The discovery of the art of compounding alloys was probably accidental. For a time, no doubt, the manipulation of copper preceded that of bronze-making. It is most likely that virgin or native copper, being found in the metal-bearing regions, it, like native gold, was hammered into shape by the use of the stone hammer, and by the accidental melting or fusing of copper ore in the fire the metal was also obtained, and the art of smelting thus discovered, its development would naturally be diligently pursued. Tin and its ores were well known to the ancient metal workers, and the union of the two would inevitably follow. The right proportion being the result of studied experiment, thus they would hit upon the compound best fitted for their wants.

Bronze henceforward was to be the inseparable companion of man, and when he began to organize communities and build cities, this alloy was an important factor in their development. It was dignified as a noble metal, for brass is honored with the second mention of all the metals referred to in the Scriptures, gold, only, taking first rank, and Tubal Cain, the first artist

named as the "Worker in Brass," carries the art to the earliest date of historical annals.

The supply of metals for the manufacture of "brass" came from adjacent territory to the place of its origin, which was undoubtedly Egypt. Chalcis and Cyprus, near by, and the mines of Cornwall in England, Spain and Gaul, all contributed their stores of wealth in metals. The Phoenecian traders being the most active in this traffic, though it is probable that the prehistoric workers in bronze obtained their supplies near at home—as in Egypt, Assyria or India.

"Bronze" and "brass" are often used synonymously, but the former is a compound of copper and tin, and the latter of copper and zinc. Now, zinc was not known to the ancients, but they discovered that when copper was subjected to heat in contact with a blanket of "calamine," an ore of zinc, the copper changed to a bright yellow color, but its exact cause was not suspected, as the extraction of metallic zinc from ores was not accomplished before the beginning of the eighteenth century, Dr. Isaac Lawson being the first to discover the process. Bronze having thus originated in Egypt; it eventually found its way to the remotest regions of the earth, as evidenced by the "finds" in ruins, tombs and temples.

But at what period the art of bronze manufacture and founding attained the perfection as exhibited in the implements, tools and statuary exhumed by modern archeological explorers, has thus far not been discovered.

Once bronze manufacture became an established art, its uses and applications extended into all the ramifications of man's existence. Its durability caused it largely to supersede the use of the more costly kinds of pottery in domestic life. It furnished the sword, lance and battle-ax for warfare. With it was fabricated the sacrificial knife that was used when offering the victim upon the altar. And of bronze was made the sepulchral implements and funereal offering used at the last rites of the dead. And with the bronze comb the dark-eyed maiden of Egypt, dressed her raven tresses as she gazed into her bronze mirror,

long before those stupendous monuments of Egyptian architecture and skill, the pyramid and the monolith, were erected.

The bronze chisel, cunningly devised to withstand the work demanded of it, not only enabled the skilled artisan of the extreme East to build his wonderful temples and monuments, but to inscribe his mysterious records on everlasting granite, that have endured to the present day. And with this implement the artists of Greece made possible those lofty conceptions of the mind, which to-day stand in matchless beauty as incomparable models, that may perhaps be feebly imitated, but can never be surpassed.

Of the works in bronze, historic and prehistoric, the quantity and magnitude is something astounding. It is supposed that the very first works of great size were made up of separate pieces or plates, hammered and shaped, and then fastened upon cores of wood or stone, yet so skillfully united that the joints were not visible.

Before referring to the technics of bronze, let us consider for a moment a few of the works in that metal which history and antiquarian researches have revealed.

The revelations of the Tombs of Egypt, the cities of Troy and Mycenae, and other cities of Greece, the buried treasures of Herculaneum and Pompeii, the traditions coming up from the ages in China and India, and the "finds" all over other parts of Asia and Europe, to say nothing of the exhumations of Mexico and South America, only serve to mystify conjecture as to the origin of the art.

Thus far, Egypt seems to have revealed the most ancient specimens, for they are accompanied with the nearest approach to authentic dates that have been discovered, as far back as the fourth dynasty. The implements, jewels, and tools taken from the tombs of the kings, show the perfection of the bronzists' work. This would bring us to about 6,000 years of antiquity, and the cast bronze turtles and crabs, which the Egyptians nearly always placed beneath the four corners of their huge Syanite monoliths, were fine specimens of the founder's art. An inter-

esting example of this can be seen in the crab's claws which project from the base of the Alexandrian obelisk in Central Park, New York. This casting cannot be less than four or five thousand years old. And the statue of Jupiter at Sparta was among the most ancient works in bronze that history records; while of the larger works, Etruria has furnished some of the finest mentioned by the ancient historian.

The discoveries of Dr. Schleimann at Mycenae in the treasury of Atreus, in 1873 to 1875, prove conclusively the degree of perfection attained by the bronze workers at that time, as the walls had been decorated with plates of bronze which, like similar furnishings of the Palace of Alkinoos, King of the Phaiakes, were fastened to the walls by nails of the same metal.

Greece was the cradle of statuary bronze. Athens and Rhodes each were said to have contained 3,000 statues, most of them of bronze, and many of thhem of gigantic size.

The Collossus of Rhodes, which stood at the entrance of the Port, was 105 feet high, and ships rode between the extended legs. This mass of metal weighed 360 tons.

Many other cities of Greece and Etruria estimated their wealth by the number of their statues. That versatile historian, Pliny, describes the wonderful bronze mirrors of Etruria, and of statues he states that Lysippus of Greece, the greatst of bronze sculptors, produced not less than 1,500 by his own hand. It was a peculiarity of this artist that in his statues he made men not as they really were, but as they seemed to be. In modeling he depended upon the judgment of the eye alone, as not delineating right, but *looking* right. His statue of Zeus at Tarrantum stood 60 feet high, while the statue of Nero, by Zenodorus at Rome, was 120 feet high.

The astounding versatility and genius of Lysippus is shown in his bronze group of Alexander and his followers, which consisted of 35 figures. The magnificent colossal head of Aphrodite in the British Museum, by Phidias, exhibits the exquisite skill of this artist. And Pliny describes his group of thirteen statues at Delphi as of exalted merit. And the bronze horses at Venice attributed to Polycles are the pride of the Venetians.

The armor of Agamemnon and the shield of Achilles are described by Homer as of the finest bronze. The chisels and cutting tools of his time were scarcely excelled by those of steel of our own day, as were also the razors of the Sabines. The work of the Greek sculptors was all executed with the hardened bronze chisel, and Humboldt obtained in Lima an antique Peruvian chisel that would cut the hardest porphyry, of which their ancient sculptors executed their elaborate bas-reliefs.

The bronze medallions of Greece and Rome could not be excelled for perfection of detail, and the inlaid statuary and vases of China date back to their most remote annals.

The sacred vessels of Solomon's Temple were not only of gold and silver, but of bronze, as were the clasps that held the curtains that covered the Tabernacle. The brazen laver, supported on figures of oxen, shows the perfection of the founder's art in that day.

The remarkable figure of the Chimera in the Museum of Florence, executed by an Etruscan artist, is a vigorous specimen of work. Those masters of statuary art, Polycleitus and Praxiteles, were celebrated for their work in bronze, though much of their genius was exhibited in marble.

When we consider the amount of bronze work of all kinds produced by the ancients, we naturally wonder what has become of it, for notwithstanding the large collections in the museums of the world, the proportion remaining is very small. There can be but one explanation to account for its disappearance, and that is, that as art declined and the appreciation of her works with it, the metal being very valuable, it was melted down and converted to baser uses.

During and after the Roman conquest, the cities of Greece were despoiled of their art treasures, and bronze techniques rapidly declined in the whole Eastern world of art. Subsequently with the advance of Christianity, and the accession of Constantine, in the fourth century, the art again began to revive, though for the most part it was confined to domestic and ecclesiastical uses.

No great works in bronze were created until the year 545, when Justinian ordered a colossal equestrian statue of himself, 30 feet in height. Gradually the art revived; but I must hasten to relieve your patience.

In the fifteenth century, Lorenzo Ghibirti modeled and cast in bronze the celebrated doors of the Florentine Baptistry, which Michael Angelo declared were worthy to be placed at the entrance to Paradise.

Of the memorial statues erected in modern times, they are almost universally of bronze. Of these, we can only mention the colossal statue erected in Paris, the Column Vendome in honor of the triumphs of the first Napoleon, which was cast from the cannon captured by him, and the recent statue erected to commemorate the establishment of the new Republic of France.

In our own country, the magnificent bronze doors of the Capitol at Washington are masterpieces of art.

The bronze fountain and group of life-size figures at Cincinnati are among the most noted, besides a number of memorial statues in the various cities of our country.

The colossal bronze statue of Liberty, by Bartholdi, and erected on Bedloe Island, New York Harbor, was presented by the French people to this country. With the pedestal, it stands 120 feet high.

As to the technics of bronze founding, the literature of this profession, I regret to say, is very meager, and a reliable treatise with an efficient grasp of the subject is not to be had. It is true, there are books and books treating of casting and founding, yet as a rule, they are far too theoretical, with an absence of practical statement, that renders them comparatively useless.

To the seeker after knowledge in the art, as an exception to this criticism, I am glad to refer to that excellent work on iron founding by Mr. Thomas D. West. But a reliable work on brass founding is yet to be printed.

Of the technics of the ancients, probably the first castings were of the simplest character, as the axe, the primitive mold being scraped or cut out of stone slabs. A specimen of this is

shown in the discovery on the Island of Harty, Kent, England, of an ancient brass founder's outfit, in which were pieces of copper and fragments of broken weapons, all ready for remelting, with molds for casting. Some of the stone molds matched in halves and fitted with dowel pins.

As the skill of the workman developed, the use and combination of various sands would naturally follow, until eventually all works in bronze came to be produced in that way, as practiced by the bronzists of the East. And the compounding of metals would come about in the same way.

The earlier mode of casting articles in the round was to make them solid, but experience, and the necessity of economy in the use of metal, would suggest coring out, and this was practiced by the Egyptians even for small pieces and figures.

The composition of the bronze of the ancients was remarkable for its uniformity. It seldom varied from ten to twelve parts tin to eighty-eight or ninety parts of copper. The so-called "tempered copper" of that time was a myth, the hardness being the result of the addition of the tin, with sometimes an accidental small quantity of iron. By heating their cutting implements to a dull red and plunging into water, with subsequent hammering, a degree of hardness and toughness could be attained sufficient for their purposes, and which would produce a very efficient tool.

The usual practice of the early founder was not to cast his work all in one piece, but in several pieces, and then to fit and unite them together afterwards by dovetailing, nails or rivets, the joints being very skilfully fitted. The furnaces and melting appliances described by Pliny were similar in principle to our own, but of course were comparatively rude of construction. They answered the purpose, however.

There is in the Berlin Museum a vase which represents the workshop of a Greek bronzist; one man is blowing the bellows, while another is raking out the fire in the furnace; two others are scraping the surface of a statue, while another is dressing off the arm of an unfinished figure, the head separate, and lying on the floor.

In the Hippodrome at Constantinople there is a Greek cast bronze in the form of three serpents, which before the heads were broken off was 20 feet high. It is hollow and cast all in one piece. The workmanship is described by Herodotus as of great beauty and skill. But it would weary you to recount the numerous castings in bronze described by the Greek and Roman writers.

It was characteristic of the Greek artists in bronze that they were not only designers and modelers, but were masters of casting and founding. Especially so was Lysippus, and Myron, whose foundry was in the Island of Delos, and Polycleitus of Aegina were both practical founders as well as artists of the highest type. These men were contemporaneous and maintained a vigorous rivalry, and their competition was as keen as that of modern times. An immense number of the productions of these artists in bronze adorned Corinth and when in the second century, B. C., Mumius burned the city, vast numbers of their statues were destroyed in the fire, the metal mingling with portions of gold, silver and lead, there resulted the historical alloy known as "Corinthian Bronze," of which the Romans claimed that many of their later works in metal were composed.

The technics and methods of modern bronze and brass foundry practice so nearly resembles that which is familiar to the gentlemen of this Association, that I will not tax your patience by enlarging upon it. I will only refer to one or two methods of statue molding and casting as a type.

The Greeks and Etruscans were very skillful in the molding and casting of cored work, and probably were acquainted with the process now called cire perdue, or "lost wax." Briefly, it is as follows:

The figure of the desired casting is first roughly modeled in clay, but slightly smaller than the future bronze. Over this, the sculptor models a skin of wax to the desired form and finish. A mixture of clay and sand wash is successively painted with a brush over the wax, until all the lines and depressions are filled up. A compound of soft clay and sand is then thickly laid over,

until sufficiently strong, with the aid of iron hoops to hold it all together. The mass is slowly dried and placed in a hot oven and thoroughly baked, the melted wax escaping through an opening made for the purpose. The space left by the wax is the intended thickness of the casting. The molten bronze is then poured in until the mold is full, the core being held in place by small bronze anchors running through mold and core. After cooling, the outer shell is broken away and the core dug out through a hole left in the base or foot of the piece. If the modeling is skillfully performed, there is very little to do except scraping or sandpapering. This process cannot be much improved upon even to-day, and has been used up to the present time. For very large or complicated designs the treatment would have to be more carefully elaborated. The equestrian statue of Louis XIV., modeled by Girardin and cast by Kellar in 1699, is a good illustration of this class, and is fully described in Diderot's Encyclopedia. I beg to submit a condensed statement of the process.

After the plaster model was completed, it was plaster molded up in sections of a size to be easily handled, in courses from the base up, each section being keyed and numbered consecutively, care being taken to properly space the parting lines of each piece until the whole was built up. Beginning then at the top, each section or block was removed and each painted on the model side, with melted wax and additional sheets of wax laid on to give the required thickness of metal, after properly arranging iron supports for the core. The mold sections were again built up from the base, and restored to their original position, the model of course being removed. The workmen then through a hole in the back of the horse plastered the inner surface of the wax with a layer of prepared loam half an inch thick; after this was dried, other layers were put on in the same way, until the core irons were buried and the loam was six inches thick. This was then reinforced with dried bricks of the same material laid in loam mortar, leaving a central space in the body of the horse in which is placed a brazier of lighted charcoal, until the whole

was thoroughly dried. The parts of smaller diameter, as the head, body and limbs of the King, were filled with the core compound in a semifluid state. After the whole was dry, the plaster sections were again removed, and the core exposed. Then, having been removed from the block sections, they were again replaced on the core and fastened to it by copper nails passing through the wax. The gates and vents composed of sticks and rods of wax, were then properly placed and secured. These served also to carry off at the base the wax as it melted in the final drying process. The next procedure was to build up the mold itself. This was done by first painting liquid loam as before, with soft brushes, so as not to injure the model surface of the wax. When this was dry subsequent coats in the same way were put on until a thickness of eight inches was obtained. This was reinforced by being built up, braced and supported, until the proper strength was assured. The wax was then melted out as in the cire perdue process, by means of a fire kindled in the kiln that was built all around the structure, and when all was ready the molten bronze was poured in at the top directly on the core, and the mold filled up. The casting came out sound and perfect. The general details relating to the construction of the base, method of securing the core and mold, and other matters, I have omitted lest I weary you.

The time occupied by Girardin in casting this work was considerably over a year. The weight was about 55,000 pounds. This statue was destroyed in the French Revolution.

The technique of general brass founding differs little from that of iron, the chief difference being in the use of crucibles for melting metal in lieu of the cupola, for the reason that we use much smaller quantities of metal and require it to be protected from oxidation in the furnace. The method of pouring brass molds, up on end, in distinction to laying the flasks flat on the floor, as with iron, is necessary to insure the passing off of the large volume of gases given out by brass compounds, especially when they contain zinc. In large or heavy castings, like bells or statuary, this rule would not of course apply.

It has often occurred to me that my brethren of the iron founding fraternity might with very good results adopt the brass founder's method of pouring his smaller cored work on end in clamped flasks. This would insure the outlet of the gases and greatly reduce the loss of castings.

In conclusion, the history of bronze is coeval with that of man. This metal has been his constant companion. It has been an indispensable adjunct in the march of his improvement and artistic devlopment. It has been a conservator of the best elements of cultured life, and exerted a potent energy in the political history of nations. And when in medieval times, despotism and superstition held its dismal sway, the beautiful inlaid tracery of bronze of the furniture of that period served as a connecting link between the artistic culture of the Old World and the higher enlightenment of the present age. In this noble metal the young Republic of the Old World joined hands with the Republic of the New in erecting a colossal monument upon our Eastern Coast which proclaims to all the nations that "Liberty enlightens the world." And as the patriots of the classical cities of antiquity gloried in the monuments erected in honor of their heroes, so we in our day, with ennobling pride, seek to perpetuate the memories of our statesmen and our warriors, as portrayed in the statues we have erected in enduring "bronze" of our Washington, our Lincoln, and our Grant.

Mr. Diven: Mr. President, I move that a vote of thanks be tendered Mr. Powell for preparing this able and interesting paper.

Motion seconded and carried.

Mr. Bell: As Mr. John M. Richardson is not present, the next paper, entitled "The Importance of Fillets and Round Corners in Modern Machinery Castings," will be read by the Secretary.

IMPORTANCE OF FILLETS AND ROUND CORNERS ON MODERN MACHINERY CASTINGS.

By JOHN M. RICHARDSON.

Take some machine tool casting, a lathe, or planer, for instance, made from 25 to 40 years ago, and compare it with one of the same class brought out at the present time by any up-to-date concern, and what is the first point of contrast noted? You will all answer, "The design." Wherein is this difference of design? It is to a great extent in the large and smoothly-rounded curves and heavy fillets everywhere present in its outline.

Broadly speaking, some of these old style castings look as though a carpenter had nailed together some sort of a foundation, and then, visiting a planing mill, had procured a quantity of moldings, and with them trimmed it very liberally wherever possible, and finally, by some flourish of the magician's wand this would-be pattern had been suddenly transformed into iron and set down in the machine shop adorned with bright red and green paint, or a combination of both, neither "a thing of beauty" nor "a joy forever."

Sharp angles, fancy moldings, panels, etc., look very nicely on doors, store counters and a great many kinds of furniture, but are decidedly out of place and likewise impracticable for cast iron.

I consider it of great importance to have a machine casting designed so that its exterior will present as smooth a surface as possible, and all angles and recesses of any kind provided with good liberal fillets.

The advantage of this does not lie along any one line, but every one of the four mechanical arts, namely, draughting, pattern making, molding and machine work, which are so closely joined and interlocked as to be but four links of a giant chain, of untold strength and value to mankind, are each and every one benefited thereby.

A drawing where this matter has received attention presents a much more finished appearance, and reflects credit on the de-

signer, for it shows that he looked ahead as far as the foundry, realizing that the design and its resultant casting bear a close relationship to one another. Many a condemned casting is such not through any fault of the molder, but rather from bad proportioning of the metal, sharp angles, no fillets, etc., directly traceable to the drafting room.

In the pattern department fillets serve a very important purpose, and now I am treading on familiar ground, and therefore can, without hesitation, give a short outline of their merits and demerits.

A fillet is actually a pattern strengthener, aside from its foundry value, provided it is composed of a substance having some tenacity in itself, and aside from this property, it is very often a time-saver also, for in fitting hubs, bosses and ribs, over curved surfaces, or, in fact, any part fitting another, where the intersection does not lie in a plane, much time and labor is required to produce a close fit, but a firm bearing can be quite easily arrived at, having, perhaps, rather open joints here and there, and here the fillet aids the patternmaker by effectually hiding the imperfection.

The molder who keeps his eyes open will notice quite a variety of materials worked into fillets on the various patterns he handles, especially if he works in a jobbing foundry. Wood, leather, lead, beeswax and putty comprise the kinds ordinarily used, and they each have their time and place, except the metallic one. A pattern being of wood has a fibrous nature, which will hold glue or any other adhesive substance, while lead has no affinity whatever for glue; so the only thing that can be employed is shellac or nails. I have used yards and yards of lead fillets, so can speak from experience, and I have seen old engine beds and their foundation boxes returned for repairs, where these fillets were fairly stripped away from the pattern; even the small bunghead wire nails used would not keep them anchored down.

Probably the finest fillet of all is made of wood, worked out of the solid pattern, having no feather edges whatever, but this is a very expensive kind, and can only be used on the finest

jobs, so in every-day practice we have to add the fillet to the pattern as a separate part.

For fillets from 1″ radius down to $\frac{1}{8}$″, leather is unquestionably the best and most practical material that can be used, and when properly applied will not peel up even with the hardest usage, and requires no nailing whatever, glue being the only agent employed. Those who condemn the leather fillet for patterns, probably do not understand the proper method of applying it. There is a sort of trick about it, to be sure, the keynote of success being hot water. Cover the back of fillet with thick glue, and place it quickly on the pattern, instantly drawing a round ended slicking tool of proper radius along its surface, bearing down hard to exude any superfluous glue, and following this with a woolen cloth wet in very hot water, to remove all pressed out by the slicker. Repeat this until not a particle of glue squeezes by the edge of the fillet, then wipe with a dry cloth.

This is really not so much of an operation as it may seem from the description and many feet of these fillets can be applied in a very short space of time.

Where it is hard to bind the leather neatly around small curves, etc., just immerse it in hot water, taking it out instantly. This renders it perfectly pliable, but it means quick work, for the thin edges will shrivel and harden at once if not immediately placed in position and burnished down as previously described. A leather fillet put on properly, with strong glue, can only be removed when dry by main force, and will then come off with fibres of the wood adhering to it, and sometimes the leather itself will keep breaking, it takes so much force to make it let go. Light patterns are strengthened by them to such an extent that nails are frequently unnecessary.

Beeswax is all right for very small fillets, and for finishing out where leather ones come together at the top edge of a rib, when the curve is very small, and for many other places. The wax is prepared by being put in a cylinder, having holes of varying diameter in one end. This is warmed and the wax forced

through with a plunger, and then applied with a warm slicking tool of the right radius.

If used too cold the fillet will not adhere firmly to the wood. In fact, it is hard to lay wax fillets satisfactorily in a cold room, for both pattern and wax are chilled to commence with, and the heated iron bearing on the top surface of the fillet only makes it difficult to communicate the heat evenly enough through the whole mass to secure a firm contact with the wood, and after the pattern has seen constant use in the foundry, the wax will peel up badly; also it is not a durable substance for a fillet if sunshine or heat of any kind strikes it to any extent.

Putty has always been used in great quantities in pattern making, and probably always will be, on account of its cheapness. Undoubtedly more feet of fillet can be applied in a given time with this substance, for a given amount, taking both the material and labor into consideration, than with anything else, but it is only adapted to cheap work, and not for standard patterns, as it is soft, easily dented, marred or bruised, besides imparting no element of strength whatever to the work. In some places plaster of paris is added to it, to increase its durability, but when this is done, it must be used immediately after mixing.

Black putty is also frequently used. This is nothing but common putty mixed with lampblack, and is employed only on cheap work, having but one coat of shellac, this being applied after the sand papering, thus comparing in color with the blacking on the pattern, and saving a second coat.

When fillets are called for having a radius above 1″ then they must be worked out of wood, and this should be done after gluing to the pattern, not before, in order to have the feather edge adhere as firmly to the work as possible. It is almost impossible not to have the edge curl away if cut out first, and then fastened to the pattern, even if the precaution is taken to have the angle of the fillet made slightly greater than that of the corner it fits, in order to cause a binding of the edges.

A mold of any considerable size can be made more safely,

quickly and easily and with a minimum of labor, where these points have been considered in the design, and carefully followed out in the pattern, and with far more chances for a perfect casting, as the danger of cracks in shrinking have been eliminated. How many castings are spoiled by having some slender part joined to a heavier one, with no fillet where they come together, thus causing a crack by the shrinkage strain at the junction, it would be hard to determine.

A pattern heavily rounded wherever possible will certainly leave the sand very much easier and with less danger of breaking the mold, thus saving labor in patching and mending, which is always a form of dead loss to the proprietor on day work, or to the molder on job work, besides being a great vexation to the workman himself.

I would go so far as to say that every edge of a pattern, except on surfaces to be machined later, should be rounded, even if the radius of curvature is so small on some light work, that it can be done entirely with sandpaper, and on brackets, ribs, heading, etc., it is much more satisfactory when one gets accustomed to it to have the edges terminate in a semi-circular section, rather than flat with the two corners somewhat rounded.

This rounding of outside surfaces is necessarily on the pattern itself, but there is something else frequently not on the pattern that is expected just as much to be on the casting, and that is, the fillets. How many molders can testify to getting patterns with a chalk mark all around every corner and rib, and this injunction in two words, "cut fillets," also marked in chalk somewhere on the surface. Once in a great while a case occurs where this is justifiable, but it should be rare. A molder does not profess to be a sculptor, and when he is forced to carve out fillets in the sand, who can blame him if, instead of being the radius of a circle they prove to be the hypothenuse of a right angled triangle. Then, too, there are often places in the mold where it is very difficult to do this, without dropping sand down into parts where it is hard work to remove it, and the result will be an imperfect casting.

Another thing I wish to mention in this connection, although it does not show on the casting except by a fin which must be clipped off before leaving the foundry, is still in the nature of a fillet. When a core is placed in position horizontally, and the cope closed down, the impression made by the core print where it joins the main pattern is liable to be crushed where it enters the body of the mold, unless the molder shaves off the corner so that, at this juncture, the core does not quite touch the edge. This shaving process is done as a foundry precaution, and varies from a slight amount on small work, to perahps $\frac{1}{8}''$ or more clearance all around where the core enters the mold, this gradually tapering off to the size made by the core print.

The fact of cores coming in the interior of a casting, and the places made by them being entirely out of sight, is sort of a "will o' the wisp" to some, who imagine that fillets are unnecessary because they do not show. This is a great error. They are just as much needed here as elsewhere, to strengthen the casting, and to help resist shrinkage strains, and should be put in of a size proportional to the casting to which they belong, but need not be made excessively large, as they frequently are on the outside of a pattern simply for the graceful effect, for these are not seen. Their place is in the core box, and not as a production of the coremaker's trowel or file. It will sometimes happen that a fillet is called for, on what is the top, or open end of a core box, thus making it impracticable for the pattern maker to provide for it. In such cases the core maker ought not to object to making it in the sand, and, as it comes within the casting, and is out of sight, a plain flat damper is all that is required, and the fillets already in the core box will be a guide for the size. Another case showing the utility of heavily rounded outlines and fillets on castings is when they undergo the cleaning process, and they will also pickle and peel more freely, as there are no sharp corners for the sand to stick into, and thus time, and the edges of cold chisels, are saved.

As we reach the machine shop, the man who snags the casting finds no sharp corners full of sand to be scraped out with old

files, and as he scours his work down with the coarse emery brick preparatory to painting, he can do much more effective service, for as the stone becomes rounded on the corners with use, it will still clean the large fillets, whereas with sharp corners it could not, and finally, when the iron filler is applied to one of these smoothly outlined castings, it can be sand papered down easily and quickly, so that, after the painting is completed, the effect, when properly done, is almost like velvet.

Mr. West: As a rule fillets are very desirable to a molder in finishing his work, and assisting him to make good looking castings. There are a few foundries in this country that make especially fine heavy work, and to assist their molders to do so, they endeavor to have tools made to fit every fillet and portion of the mold.

At this point the convention adjourned for the day.

WEDNESDAY MORNING, MAY 17, 1899.

Wednesday morning discussion was resumed of Mr. Richardson's paper, presented the previous evening.

Mr. Groves: I think Mr. West, in drawing attention to the lack of system in the sizes of fillets, has touched upon a point of very great importance to the foundry trade in general. We now have standardized test bars, if some one would take up the question of standardized fillets, it might be very desirable.

I, for one, think it is advisable to use fillets in every instance that you can. We always use them where we want to put strength; and the reason is this: in castings with square corners, the molecules of metal arrange themselves in the sides in straight lines, meeting together at an angle from the inner to the outer corner, thus forming a straight, porous passage, easily widened, and through which the contents shoot when the structure is subjected to internal pressure. That is the reason why so many castings with square corners are defective. When, however, the corners are properly filleted, the molecules, or crystals of metal, range themselves in continuous, curved lines, each row overlapping the other, thus making the corners of equal strength and integrity to

any other part of the casting. I agree, therefore, with Mr. Richardson, that fillets in all castings are necessary, and we are indetbed to him for emphasizing this important point in modern fcundry practice.

Mr. Diven: I understand that these fillets are used to strengthen the machinery, help the machinist and make the castings smoother.

Mr. West: With regard to the designing of fillets it is necessary that the thickness of the casting be considered. If you get fillets too large you may have the evil of shrinkage come in, to leave a hole in the casting, and that is a point on which the foundry manager who has charge of the casting should be consulted.

Mr. Dyer: In the use of fillets we find that these take care of themselves very well. After making some castings without fillets we concluded we had better put fillets on all castings where strength was required, and it so impressed us that we will not overlook this again.

Mr. Diven: In our jobbing shop we find that when there are turned ends we like them square, although we fillet all edges that we possibly can.

Mr. Bell: The foundry business is very peculiar in that it is hardly possible for the designer to make arbitrary rules in regard to these matters and the fillet is an important part. All foundrymen know that if there is one part weaker than another it is the point separated at right angles. These are very peculiar questions but you can lay down no rule as to how these things should be done; they must ever remain a matter of good judgment.

Moved and seconded that a vote of thanks be tendered Mr. Richardson for his paper.

Carried.

Moved and seconded that the meeting adjourn.

Carried.

WEDNESDAY AFTERNOON.

The trip on Wednesday afternoon was one of the most memorable which has ever been taken by those in attendance at any convention. The visitors were taken by special train provided by the Westinghouse Company, first of all to the air-brake plant at Wilmerding, and then to the Westinghouse Machine Company at East Pittsburg.

The foundry of the air-brake plant was first inspected, and the very original method of handling the work, surprised all those who had never seen it before. The fact that much, if not all, of the work made here is duplicated over and over again has made it possible to inaugurate original methods, and as a result much of it is done by machinery.

There are four large cupolas, one always being kept in reserve, and the other three being used all day. Their works are kept running continuously, night as well as day, the laborers working three shifts of eight hours each, one of the cupolas being worked for each shift.

After making their investigation of the foundry, the visitors passed on through the brass foundry and other departments of the air-brake works, and were given every opportunity to inspect in the fullest detail all the many operations in the manufacture of air-brakes in one of the largest manufacturing establishments in the world, and where all of these processes are systematized to a nicety; in fact, one of the chief features of the visit to this plant, and the one which impressed itself upon the minds of those who had an opportunity to visit it, is the amount of ingenuity displayed in this direction.

After leaving Wilmerding the party proceeded to East Pittsburg, the locomotive running on the track between the two places and drawing the regular cars of the Pennsylvania Railroad Company, being operated by electricity.

In the foundry here the work is also systematized to quite an extent, and has become quite remarkable for some of its methods of making engine cylinders, and for the complex character of the

work made and turned out in green sand. Much of the success of the systems and work done at East Pittsburg is attributed to the skill and ingenuity of the late H. H. Garrett, their foundry superintendent. While visiting these works at East Pittsburg a very delightful lunch was served, and thoroughly enjoyed.

THURSDAY MORNING, MAY 18, 1899.

Session called to order at 10:30 a. m.

The first paper read was by Prof. Albert W. Smith, entitled "The Utility of Chemically Standardized Iron Samples."

THE UTILITY OF CHEMICALLY STANDARDIZED IRON SAMPLES.

By ALBERT W. SMITH.

I believe the foundrymen are among the latest of the few American manufacturers who begin to realize the manifest advantages of a chemical control over their processes, and hence are becoming interested in those things which tend to make chemical analyses of iron and iron products more accurate and available. Furthermore, grading iron by its chemical composition must eventually take the place of the old methods of grading by fracture, a method devised as long ago as the starting time of pig iron itself, and having long since outlived its proper day of guesswork and chance.

In taking up any new process of manufacture, difficulties are always to be encountered before success and smooth sailing are achieved. Even in applying new modifications to old methods, the same holds true, and often long discouragement attends the introduction of those changes which we are sure are to be eventually valuable, when sufficiently elaborated and understood.

For these reasons, the application of a knowledge of chemistry to foundry practice does not always start with the most complete success desirable, and I presume those of you who have attempted to regulate your iron mixtures by a knowledge of the chemical composition of the various irons to be mixed, have already passed through just such discouraging experiences, or are now occupied in overcoming them. The use of the chemical composition of pig iron as a basis for proper blending to produce any desired quality of casting, while the only accurate and scientific method, is beset at the start with grave difficulties, so serious, in fact, that to many I imagine they have appeared insurmountable.

The first theory governing such application was, that a given chemical composition always produced the same quality of iron. As a matter of fact, iron and the elements with which it is associated in pig metal, form many differing molecular compounds,

so that ultimate chemical composition does not afford all the information necessary for our purpose. Carbon and iron possess the property in common with many other carbon compounds, of forming a variety of substances possessing very different properties and still containing identical proportions of carbon. It was early learned that two irons may have identical ultimate chemical composition, and still have the widest differing physical properties. Something more must be known than the chemical composition of the various grades of iron available, in order to successfully make any desired casting from them. The main circumstance that influences the manner of combination of these elements to form the various compounds possible, is the character of their physical treatment, and especially their heat treatment. The soft gray iron may have just the same proportion of carbon as the hardest chilled white iron, so that we must amend our theory somewhat to this form: "Samples of iron having identical chemical composition and physical treatment, will possess identical physical properties." In this form I believe all experience has shown the proposition to be absolutely correct and a safe guide in practice; but in its application numerous pitfalls must be avoided. Perhaps the difficulties most commonly encountered are two: First, that the analysis sent by the iron manufacturer does not represent the average composition of the shipment, due to improper or careless sampling or loading, or that the analysis, made from a proper sample, was incorrect. Second, that the iron, in passing through the foundry smelter, undergoes a chemical change, losing silicon, and possibly gaining or losing other elements.

The latter of these causes of failure in the application of our theory depends for its removal wholly with the founder and his chemist. In almost all cases where iron is melted, some change in chemical composition occurs, and the amount and kind of this change varies with the conditions of melting. The first requisite to success in applying the theory to foundry practice, then, is to study the nature and amount of those chemical changes which take place under the various conditions of smelt-

ing employed in the foundry under consideration. When these changes are once understood and their approximate quantity determined, allowance may be made for them in calculating the mixture to be employed.

The first cause mentioned, that of inaccurate knowledge of chemical composition, needs for its complete removal the employment by the founders of competent and properly trained chemical assistance. So long as entire dependency for a knowledge of the chemical composition of his stock is placed on the iron producer, trouble is always likely to occur. Not that iron-makers would wilfully send out erroneous analyses, but where there is no checking process on either loading, sampling or analysis, carelessness in one or more of these is likely to follow. No matter how well-intentioned the furnaceman may be, if it is known that his customer keeps no control over what he buys, carelessness in loading a shipment, in sampling or analysis is apt to creep in, because employes entrusted with these details are often not so interested in accuracy as they should be, and soon learn where they can be careless without detection. On the other hand, if it is known that every shipment, upon its arrival at the foundry will be properly sampled and analyzed by a man whose results are most liable to be always correct, the material as it arrives at the foundry will seldom be other than as contracted for. In the case of small foundries, where the expense of a chemist's salary could not be afforded, combination could be resorted to in this one item.

As in other commodities, there are different grades of chemists. How is the selection of the right quality to be made? Here, as elsewhere, price is some indication of quality; and I know of no place where low price will be more conducive to ultimate high cost. In general, chemists available for iron laboratories are to be divided into two classes—those who have had a scientific, technical training and understand the principles and theory underlying their chemical practice, and those who were trained solely as to their fingers and make their analyses wholly mechanically.

Of course the two classes grade into each other, and, while an occasional technical graduate degenerates to mediocrity or settles permanently into the common rut of cheap machine-like daily routine, often an exceptionally energetic and intelligent non-graduate will succeed in training himself, by reading and home study, so as to rise to the top level of usefulness. We are all familiar with brilliant examples from these exceptions to the general law. But the safer person to choose as the head of the foundry or furnace laboratory will be the technical graduate, and one of those who has the self-respect to demand a proper salary. Having now secured proper chemical assistance, what duties are we to allot to him? If he is really well trained, his sphere of usefulness should be a large and important one. The duties of the furnace and foundry chemist are too often limited to routine analyses of furnace materials and products, and thus he is given no opportunity to render available his scientific training, aside from his ability to make a certain number of analyses daily. Even in the decision as to what analyses shall be made, his judgment is not consulted, and, in fact, this decision is often made by the business manager, whose knowledge of the relative value of the different analyses is usually a limited one. American iron and steel manufacture, and especially American blast furnace practice is characterized by large output and low fuel consumption. Tonnage is the watchword and keynote of success. This requires low labor cost, and the application of numerous labor-saving machines and highly specialized system throughout. Everything connected with the establishment is made to do its utmost work possible in a given space of time. The chemist has not wholly escaped this spirit of superlative work pressure. He must get out his analyses quicker and make more of them. The first result has been accomplished by devising new and rapid methods of analysis, which are a credit to the ingenuity and patient research of many workers in this field, but mainly of our own American graduates. The second result has been attained in

some cases by working longer hours, but in some establishments, I am forced to confess, by half doing the analyses.

At some works the practice exists of keeping record of the total expense of maintaining the laboratory, and this sum total is divided by the whole number of analyses made during this time, the quotient, or cost per determination, being apparently taken as an index of the efficiency of the laboratory! An equally sensible analogy would be to value the services of one physician by the average cost per pill administered, regardless of results. I am informed that in some cases this efficiency index has been squeezed down as low as fifteen cents. A chemist in such employ, recognizing the fact that he must keep this cost per determination low to please his superiors, exerts himself to the utmost to swell the number of analyses made, and, no doubt, grinds them out as best he can under such influences, but with how much regard for accuracy and real value to practical application. I wish also to say that there are many laboratories which are not influenced by this expensive fallacy, and where accuracy is the first requirement. In all such places the cost per determination may be very high, but the actual value to the company is correspondingly large, and costly controversies over disputed results are rare or unknown. The very fact that results come from certain laboratories stamps them as correct and allows them to pass unchallenged. This is the reputation to be envied and strived for in all chemical work.

We are all familiar with the trouble caused by poor chemical work. An instance may be mentioned of a company which had shipped some 1,500 tons of iron, all reported by the furnace chemist as within the contract specifications. The iron was rejected by the buyer and the furnace chemist's analysis proven much in error, resulting in a loss to the furnace company in freight demurrage charges and sacrifice in price of nearly $2,000, an amount probably exceeding the cost of maintaining the laboratory a whole year. We will not even mention the loss in reputation which such a blunder entails.

Another factor tending to produce unsatisfactory conditions in furnace laboratories is the low price paid responsible employes

in the laboratory. At many furnaces the wages paid the chemists are little, if any better than those of the subordinate clerk in the office, or stove-tender, or hot-blast man, and this notwithstanding the fact that the chemist has, or should have, spent four years in preparation at a scientific or technical school, and is entitled to be placed on a plane with the doctor, lawyer, or any learned profession. The result is that properly trained men do not remain in such positions, but use them for a few months only as a sort of experience school, and the places must eventually be filled with the finger-trained assistant boy, or be continually on the change in its occupant. This assistant often manages to keep things a going well for a time, as long as materials and chemicals remain uniform, but he has learned his methods only in a mechanical way, and, as every chemist learns sooner or later, there are little irregularities occurring which require some general foundation chemical knowledge for their removal, and it is here that the untrained man is likely to run his company into trouble, and one such trouble is often more expensive in dollars, not to mention loss in mental worry, than many chemists' salaries.

Again, it is not to be implied that none but college graduates will succeed as iron chemists, but the employment in so responsible positions as that of furnace or foundry chemist of men or boys with no scientific education other than what is commonly acquired by a few years' experience as laboratory boy, crusher, weigher, etc., is questionable economic policy, as results are constantly showing.

The position, then, of chemist in the iron and steel industry should be one of dignity as it already is one of high responsibilities. Further than this, let your chemist be given opportunity to utilize, for the benefit of his employer, his scientific training in other ways than the mere routine of daily analyses. Problems are always arising in every sort of manufacturing plant, for the solution of which such a proper scientific training will be serviceable and often necessary. Let the chemist express an opinion as to what analyses had best be made. Certain others are useful,

but not absolutely necessary, and still others are not entirely useless.

These are my observations of errors made by iron manufacturers in the treatment of their chemical assistance, and of the causes of trouble in the utilization of chemical analyses of iron as a means for determining foundry mixtures and a guide in foundry practice, and it is to be hoped that the foundrymen will avoid these mistakes at the start.

Having begun in the best way in the treatment of laboratory and chemist, every opportunity to insure accuracy should be utilized, and no chemist's services should be retained who is not entirely sure of all of his results. If rapidity of work and number of determination on the one hand, or accuracy on the other must be sacrificed, retain accuracy.

In the past, one method of ensuring this highest degree of accuracy in the best laboratories has been the practice of sending out occasional samples of various products to independent chemists, in order to obtain a check on analyses. Frequently the expense and bother of this plan, while necessary to the best results, are considerable, and the American Foundrymen's Association is certainly to be congratulated upon having found and successfully put in operation a plan by which their difficulties are overcome, retaining at the same time all the advantages of the old way, and more. The starting of the bureau of national standards for analyzed pig iron by a committee of your Association has marked a new era in the accuracy, and hence the general value of iron analyses. The value of such properly analyzed samples is so apparent to the chemist as to appear self-evident and to need no further discussion, and is invaluable in very many ways.

In all volumetric methods, the rapid and commonly employed ones, solutions must be standardized with some substance of accurately known composition. Such solutions are most accurately prepared by using as a standard, material of the same approximate composition and character as that for the analysis of which the solution is to be employed. With this in view, the

committee has secured such a variety of kinds of iron for the standard samples as to cover all ordinary needs of foundry or furnace practice.

Even for gravimetric determinations, it is always a satisfaction and a guaranty of accuracy to the chemist to possess material whose composition is accurately known, because by occasionally analyzing this along with the routine work, any harmful impurities of reagents, or other causes of inaccuracy, are at once and most certainly detected. Such samples are also in constant demand for color-carbon comparison standards.

The care and patience with which these samples were made at the foundry, and their method of casting to ensure uniformity of composition, were almost sufficient to do away with the need of further care, but even this was not assumed to be enough. The samples were cut to a powder, all sifted thoroughly, then spread out on large glazed surfaces and intimately mixed.

In filling the individual bottles, they were all spread out on this same glazed sheet, and from each shovelful taken up a very little was sifted into each bottle. The contents of every single bottle of this, upon proper mixing by the purchaser upon its receipt from the express agent, must be exactly the same as every other bottle in the whole sample made, and all results obtained have shown this end to have been achieved.

DISCUSSION.

Mr. West: Among the many valuable points in Prof. Smith's paper, which, of course, is largely of a chemical nature, there is one which the foundrymen know from experience to be true, and that is where he says: "The main circumstance which influences the manner of combination of these elements to form the various compounds possible, is the character of their physical treatment, and especially their heat treatment," and this goes on to show that we must have similar treatment to produce similar results. At the outset of this discussion on the physical properties of iron few know that difference in the pouring temperature of iron could often greatly affect the chill, etc., of

iron. It was not very long ago that we had a paper that gave the chill in thousands of an inch, to show what might be expected of the iron. Such deductions would not have been drawn had that writer known that by pouring at different temperatures a difference of $\frac{1}{4}$ inch could be made in the chill of the $\frac{1}{2}$ inch bar illustrated, a point which will sustain Prof. Smith's statement of like physical treatment producing like results.

Mr. Bauer: There is one thought that struck me as being very essential in this matter, referred to by Prof. Smith, i. e., in what way could these standardized samples be of the greatest utility. There is no doubt that the technical graduate is the better man to engage but the salary for such a man is too excessive to warrant his employment by the smaller foundrymen. To these same small foundrymen these drillings ought to be of especial benefit. But a satisfactory man could be obtained, at a reasonable expense, who, by comparing his work with these standardized samples, can obtain results which would be of material assistance in making mixtures and checking up the pig iron on its arrival. Don't think that I believe these standards will make chemists, because chemists work with the head as well as the hands, and this same class is not within reach of the smaller foundryman. The samples will certainly prove a step in the right direction and higher accuracy will result in foundry chemistry.

"The Advantages of an Upper Floor Foundry for Light Castings," by Mr. C. J. Wolff was then read.

THE ADVANTAGES OF A FOUNDRY FOR LIGHT CASTINGS ON AN UPPER FLOOR.

By C. J. WOLFF.

In the evolution of foundry practice, much good has resulted from the meeting of Foundrymen, in convention and in local associations, in exchanging experiences in the various details of founding.

The foundry of ten years ago was conducted on more selfish principles than that of to-day, much to the disadvantage of the proprietor of such an establishment.

It properly becomes each of us to contribute to the store of useful knowledge and experience, and as we think our iron foundry a departure from the ordinary practice followed, I thought it might be found interesting to some of you to hear and know about an iron foundry melting 70 to 80 tons per day, with a clear molding floor of 125 feet by 540 feet long, located on the third floor.

The foundry, being above the house tops in the neighborhood, always has unobstructed light, and the air is so pure that in summer the birds seem to think it a nice place to perch on the beams of the roof construction and watch the molders, while singing their little songs to an appreciative audience.

The molders do not leave their work so frequently for refreshments, and are not disturbed by visiting friends and inquisitive strangers. The dampness arising from ground molding floors, which is often the cause of rheumatism and colds, is avoided.

The smoke and steam incident to starting the cupola and casting iron are quickly dissipated by the breeze that has unobstructed passage through the windows, and being so high above ground does not bother people living in the neighborhood; making it at all times a pleasant place to work in.

The building is of mill construction; the foundry floor consists first of a 3″ matched floor on the joists; above this is a coating of tar paper, then a cedar block pavement 4″ high,

bonded together and filled with tar and gravel, in the usual way you have seen them laid on our city streets. The molding sand covers this, the dampness of which is sufficient protection.

This forms the molding floor. The floor around the cupola is made of steel beams for joists, with brick arches between same; this is covered with an ash cement and makes a floor upon which the bottom of cupola can be dropped without any danger of fire.

The cupolas, of which there are two, are situated near one side of foundry at about equal distance from each other and from the ends of the building. The cupolas stand on foundations of brick, built up from the ground, which are used for vault purposes on the lower floor.

The charging floor or scaffold is of iron on steel beams, large enough to hold pig iron and coke for the day's melt, which is taken up in the forenoon, so when the blast is on, the charging is done with ease and dispatch.

The blowers are placed on the ground floor with the blast pipes running up to the cupolas. The jarring effect, caused by charging the cupola, and the vibrations of blowers, having no bearing on foundry floor, do not in the least jar the molding floors.

The foundry is built with clear story in the middle like most foundries are now put up. The roof is supported by steel truss work with a span of 60 feet in middle of transverse section, thus leaving 32 feet on each side of trussed section. The posts in foundry, supporting the trussed roof are of cast iron, and do not interfere with molding floors, as they are alongside of gangway. These iron posts also support an overhead "I" beam tram rail, on which the trolleys which carry the bull ladles travel, for distributing the molten iron to the molders throughout the foundry. This track system is so constructed that iron can be taken from one cupola to either extremity of the foundry. One man can with ease pull a ladle holding 800 pounds of iron.

This system of handling iron does not jar the floor. The steam elevators deliver pig iron and coke to the charging floors

of cupolas, and the trip from ground floor to scaffold does not take much longer than to hoist material from ground to scaffold of cupola in foundry situated on ground floor. Iron and coke can be piled contiguous and easy of access to elevators.

The castings are taken down to cleaning room on a belt elevator on the opposite side of foundry. The molders put up their work in the morning and early afternoon, and after pouring off, they go home. A night gang shake out castings and wet down sand. When the molder comes to work in the morning his sand heap is ready for him, and the castings have all been taken away in hand trucks early in the morning; each truck holding the castings made by one molder. The castings are checked up on leaving foundry and again in cleaning room. There is a steam elevator back of each cupola, and one belt driven one. These three elevators take care of all castings, new molding sand, pig iron and coke, together with the needs of the departments on second and first floors.

There is a large range boiler and tank shop and machine shop and other works connected with the preparation of castings for enameling, on second floor. These departments are never troubled by dropping sand or smoke or steam from foundry, thus making this second floor as good for any use as if there were no foundry above it.

The first floor is used for finished stock, shipping room, rattle room and enameling shop. A basement at one end of the factory contains the supply of sand. There are no long hauls in disposing of castings from foundry; they simply need to be lowered, which does not take much power. We make castings up to 800 pounds in weight, using a number of three-ton traveling cranes.

Incipient fires are very unusual, and we do not think our foundry at all dangerous. Our insurance rate for foundry is not increased by reason of our location.

We have a pattern house across a 16-foot alley, connected with foundry by an iron bridge. We had a disastrous fire some years ago on a Christmas eve—its origin was unknown. Some heavy wooden truss work holding the roof spans contributed

to the spread of the fire, together with a 4" water main in the street, being wholly inadequate as a supply. The pattern house, which contained all our master and many working patterns, was not burned, which proved a blessing in our misfortune. In rebuilding we used iron roof construction and effected some other improvements, such as building two fire walls with iron doors, thus dividing the building into three sections, but while working, practically one large room.

Having started this style of foundry 18 years ago, as an experiment, much to the amusement of our neighboring foundry friends, we found it to have so many advantages that, when 12 years ago we needed a larger foundry, we built our present factory, and have since had many inquiries from people contemplating building new foundries, many of whom have followed our example.

Among the advantages we consider we have are, the great economy in ground covered, the protection against obnoxious and intrusive visitors, the inconvenience for the men to leave their work readily, and also the means afforded for better light and air.

DISCUSSION.

Mr. Magee: I would like to ask Mr. Wolff how he operates his dump.

Mr. Wolff: Directly on the floor, protected by ash cement.

Mr. Groves: I would like to ask Mr. Wolff what kind of work he does.

Mr. Wolff: Our castings are largely such castings as are used in the plumbing business, soil pipes, bath tubs, waste bowls, etc.

Mr. Bell: The next paper will be "An Improved Method for Setting up Brass Furnaces," by Eli Millett. This paper was read by the Secretary in Mr. Millett's absence.

THE CONSTRUCTION OF BRASS MELTING FURNACES.

BY E. MILLETT.

Our idea in this paper is not to show how cheap furnaces can be built, nor how many tons of metal can be melted in five minutes.

We think that the brass foundry should be as well equipped as the iron foundry. The old cupola, blower and crane have all made way for the modern ones. The same is true of the old-fashioned core ovens; they also had to make way when the now well known Millett oven put in its appearance, and which

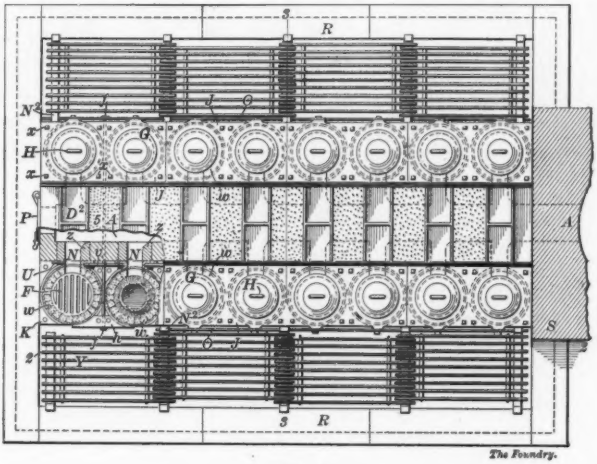


FIG. 1

is now rapidly replacing the old oven all over the world.

The old brass melting furnaces, with their brick piers, which are always tumbling down, are being replaced by the furnaces herein illustrated, for which letters patent have been granted to Messrs. E. P. Marsh and E. Millett, of Springfield, Mass.

Fig. 1 is a plan view of the arrangement, showing a double row of furnaces, 16 in number. Between each pair of furnaces is

seen the iron scrap box, with partition in the middle, and gratings over the ashpits at each side. At the lower left hand corner are two furnaces shown in section. Here may be seen the individual flues N, connecting the furnaces with the main flue, which runs along under the scrap boxes to the stack, a section of which is shown at the extreme right.

Fig. 2 shows a single row of furnaces, the arrangement of the transverse and longitudinal I beams, drop grates, etc.

Fig. 3 is a section through line 3—3, Fig. 2, looking from the

FIG. 2

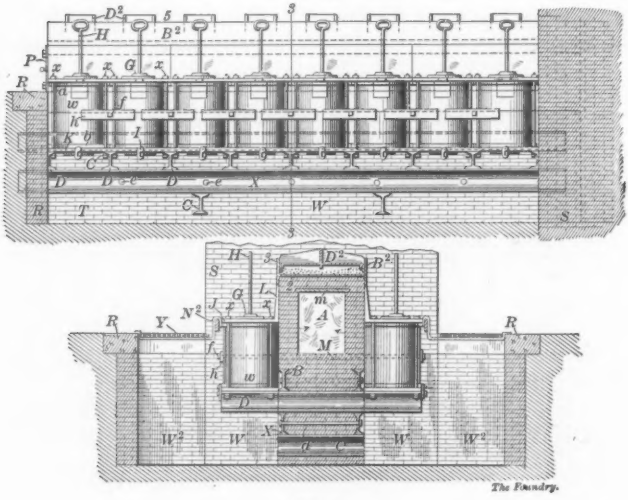


FIG. 3

end of the structure opposite the chimney. Here is plainly shown the grating Y, over the ash pits, the iron top of furnace, extending up to the inner side against the brick work of the main flue, and supporting the iron top which holds and protects the brick work, and upon which the iron scrap boxes set.

Fig. 4 is a vertical sectional view of the central portion of the structure through one of the furnaces, the pit wall at one side, and the grating extending between the furnace and wall, the main flue being shown at the right.

Fig. 5 is a prospective view illustrating the details of the construction of the furnace supporting devices, the upper and lower furnace-plates, and cylinder casings and uniting devices serving to simultaneously bind the furnaces on the opposite sides of the superstructure to the latter. To adjust these parts in position, the casings are set down on the lower base plate, and the top plate is then set down on the casings, the long upright bolts extending through the holes, as shown, when the whole is firmly screwed together.

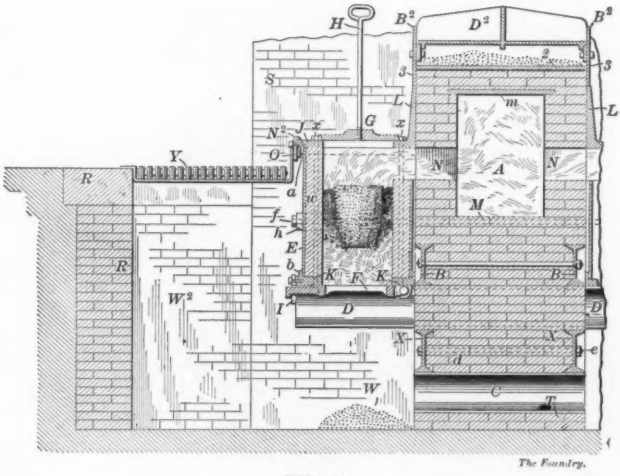


FIG. 4

Fig. 6 is a prospective view of one complete top frame and part of a second one, which covers the top and encloses a portion of the side walls of the brick superstructure which forms the main flue, and also the individual flues, as shown in Fig. 4.

Fig. 7 is a prospective view of one of the metal-holding boxes, which are supported on the top frame, Fig. 6.

The construction embodies several furnaces arranged on oppostie sides of a main flue running longitudinally between them. These furnaces are supported upon a substructure or base, which is practically indestructible, for it consists of ma-

sonry and wrought iron I beams, running lengthwise and crosswise within and on the base.

The main furnace flue, which connects with chimney, runs along over the top of the base between the lines of furnaces, and a suitable flue connects each furnace with the main flue.

The top set of I beams, running crosswise on the base, project out beyond the sides of said base. Resting on these

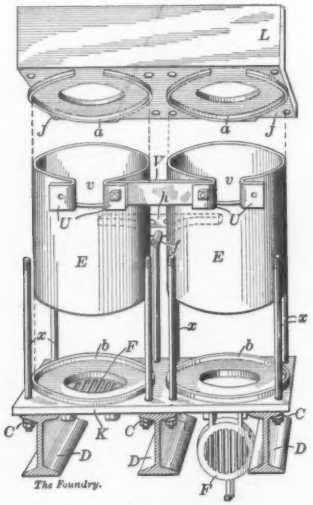


FIG. 5.

beams are the furnaces, which are bolted through the top and bottom plates to the beams. Therefore, no use that the furnaces themselves may be subjected to can vary the proper condition of the base, as to supporting the furnaces perfectly in place.

The furnaces are also united by connecting straps, front and back. Each furnace is provided with a grate, hung and supported in the usual way. The pits are covered with iron grating, and this, with the absence of brick piers, assures an equal distribution of draught. It also enables the melter to instantly detect any leakage of metal from the pots.

The main flue is carried up somewhat above the top of the furnaces, and is well covered with iron plates and masonry. On this is placed a cast iron box opposite each furnace for holding metal to be used in the furnace.

This last arrangement provides for the laying of the metal into proper charges for each crucible, and placing them in each box. By doing this greater care can be exercised in the mixture of metal for each crucible than is possible when the metals are strewn around the floor of the foundry, as is generally done.

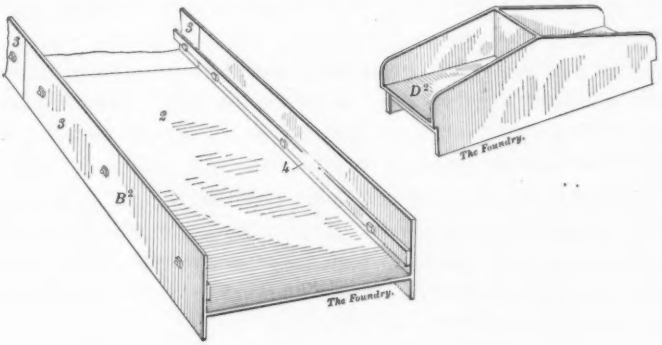


FIG. 6.

The provision of a comparatively large main flue, which answers for all the furnaces, and which gives a comparatively uniform draught, insures a uniform speed, so to speak, for melting the metal in all the pots.

A plant, comprising eighteen furnaces, arranged on the above plan, has been in constant use in the foundry of the E. Stebbins Manufacturing Co., Springfield, Mass., for about a year, and it has there been proven that the melting of metals is much greater and thereby more economical by this construction of furnaces than by furnaces ordinarily used.

DISCUSSION.

Mr. Walker: If I talk very long you will find out how little I know about brass furnaces. The paper states that letters patent have been granted. Now we look around a little and see how

other people do things, and have almost this same thing in our foundry, but support the furnaces differently. Instead of using I-beams underneath, our furnace is hung from the beams above, which I think is much more simple. The manner of supporting a furnace seems hardly important enough to patent, because other good ways could be found to do that, other than the way mentioned in the paper. We have an ash pan hung close under the furnace to receive the ashes, instead of allowing them to fall to the floor, and thus we avoid a good deal of dirt and dust. When the pan becomes filled two men can carry it away and dump the ashes in a car near by.

Mr. Johnston: Mr. President, I would like to ask a question which perhaps does not refer directly to the paper under discussion. What has been the experience as to natural draught or forced draught in brass furnaces?

Mr. Wolff: In our brass furnaces we have forced draught in such a way that the fan blows into the chimney at an angle which causes a suction. This has been found to increase the draught very much and melts much hotter than before could be obtained by the natural chimney draught.

Mr. I. W. Frank: Gentlemen, I have two announcements to make on behalf of the Entertainment Committee. By an oversight the Westinghouse Air-Brake Co. were not given credit for the excursion to the Westinghouse interests yesterday afternoon, as this was provided for solely by them. Owing to the rapid rising of the river it has been thought unsafe to attempt to make the trip to Homestead this afternoon by boat and the committee will try and make arrangements to take the party by trolley cars. We will be able to reach Homestead in good time and it is likely this trip will be supplemented with a trip to Calhoun Park.

Mr. Bell: The next paper will be one entitled "The Deceptive Fracture of Pig Iron," by Mr. Thos. D. West.

THE DECEPTIVE FRACTURE OF PIG IRON.

By THOMAS D. WEST.

Progressive furnacemen and foundrymen have experienced few changes in their practice that have been more radical in character or far-reaching in benefit than those made by the adoption of chemical analysis to correctly define the grade of pig iron. The change was such a common-sense one that many are annoyed to think that in this age of science they had not always utilized chemistry in their practice. When we think back to the time that all furnacemen and founders were guided wholly by the appearance of fractures, instead of knowing the chemical analysis of their pig iron, we naturally have a right to wonder how we ever succeeded in business, and not until we bring to mind the old-time prices paid for castings, can we realize why commercial success was at all possible to many following the old school methods of judging the grade of pig iron.

While the benefits obtained by adopting chemical analysis in foundry practice are generally very great, the advance has been slow. This is on account of the prejudice, selfishness and conservatism that all new departures in any calling must meet and set aside. The opposition that existed, and is yet in force to-day, against the adoption of grading by chemical analysis, is best known to its leading advocates. The fact that many founders still adhere to the old-school practice of judging pig iron by its fracture, causes some to suffer losses or meet difficulties that would not exist did all founders understand the utility and value of chemical analysis in defining the grade of iron, and follow its dictation in their practice. It is often interesting to investigate the grounds for rejecting the new-school practice, that members of the old, set up against its advocates. Not long ago, as an example, in discussing the merits of working by chemical analysis with an old experienced founder, who had never mixed his metals by this method, he expressed the belief that if a cast of nice open-grained pig iron did not give a softer

iron than a close-grained pig mixture, it was because of some local condition not being controlled; as, for example, he claimed that the cupola might not have been daubed properly, or the bed not well lighted before the iron was charged, or the charge might not have been placed evenly, or that the stock hung up. Then, again, he claimed that it might be due to other conditions, such as to be found in bad scrap iron, changeable weather, difference in fuel, fluxes, or variable blast pressures, to cause fast or slow melting, etc. While, as practical foundrymen, we know that such varying conditions may at all times affect mixtures, and cause a soft iron to be hard, we are forced to confess that the old-school fellows may go along for years, if they are in any way prejudiced against the new-school practice, before events may transpire to convince them that by following chemical analysis they will greatly decrease their mishaps, for the simple reason that if an open cast of pig metal does happen to give them a hard iron, they have nearly a dozen evils or excuses to which they can charge their poor results. A study of this phase of the subject should explain why some are slow to accept chemical analysis in selecting and mixing their pig irons, and also that whenever it suits the self-interest of any to prejudice the utility of chemistry in the mind of the old-school founder, they can easily do so by taking advantage of their prejudice and want of knowledge which the new school possesses.

There are several ways in which self-interest can retard the progress of chemical analysis in founding. As an example, we will cite two cases. The first lies in the power of furnacemen, knowing the utility of chemical analysis and lack of that knowledge by the old-school foundrymen. To illustrate how the latter may be duped by making them think their practice correct: A well-known firm, standing high in its ability to cast heavy machinery, recently sent an order to a furnaceman for one car of a strictly all open-grade iron to make strong castings for a special job. The writer was consulted as to the analysis necessary, as the furnaceman knew he could select the open iron in almost any grade. Upon learning the character of the casting

required from the furnaceman, the writer recommended silicon between 1.00 and 1.25, with sulphur about .030. A car of as beautiful open-grained coke iron as was ever seen was sent to the founder. Its results pleased him so much that in a short time the second order, "Send me another car of strictly No. 1 iron, same as last," came in. The furnaceman, knowing the utility of chemical analyses, referred to his books and duplicated his last analyses, being careful, of course, to load nothing but an all No. 1 open-grained iron, as, if he had sent a close-grained iron, it would have been condemned. Now, this furnaceman is not

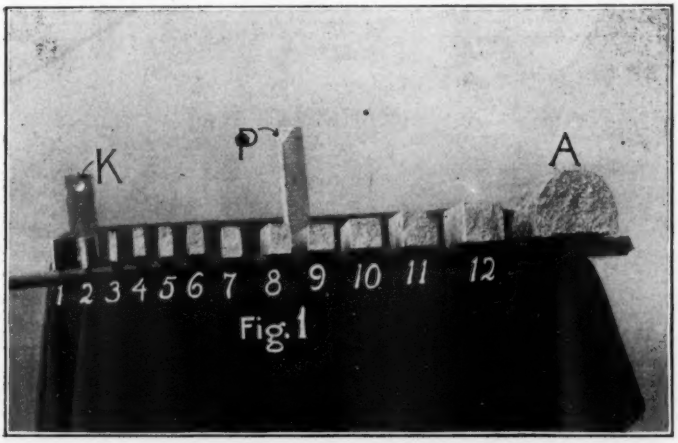


Fig. 1

going out of his way to advocate the utility of chemical analyses to that foundryman, and it would be almost useless for anyone else to attempt to do so, as that founder is stubborn in the belief that it is the open-grained iron of that peculiar brand which was wholly responsible for obtaining the results desired. Then again, should this founder change to another furnaceman, on account of a difference in price, who might not have had the forethought to consult some expert of the new school in regard to analyses, the chances are that his open-grained iron would have given him too weak a result in his castings; but as long as this founder had his open-grained iron, he could turn to

changes in the fuel, scrap irons, blast, weather, methods of charging, etc., to make excuses for his ill results, and not until such a paper as this, exposing the true cause of his trouble, might by chance fall into his hands, is there any hope of his being made a follower of the new-school practice.

The second illustration of where self-interest has retarded the advance of chemical analysis, lies in the advocating of the use of testing machines as affording the founder sufficient means to regulate his mixtures, without resorting to chemical analysis.

Testing machines have their place, and most founders should possess one; but the practice of taking advantage of the preju-

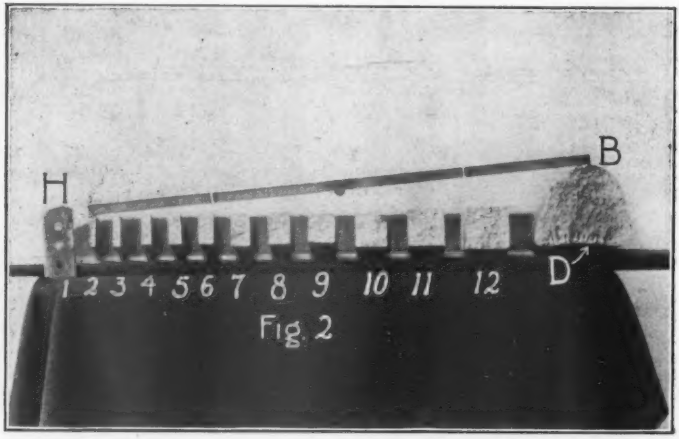


Fig. 2

dice, etc., of the old-school methods to antagonize the advance and true utility of chemical analysis in the self-interest of a more rapid sale of testing machines, is to be deplored.

The foundation of the old-school method in regulating mixtures is based on the belief that the appearance of pig fractures truly defines the character of iron as to the degree of hardness. The founder's own experience in knowing that he can make soft and hard castings from the same ladle and at one pouring, if he choose to so construct his molds, should be sufficient to prove to him why it is possible for two furnace casts of pig metal that are

alike in chemical analysis, or will give the same results when melted, to differ so widely in appearance that the fracture from the one cast will seem close-grained or hard in the pig, while the other will be the reverse. A founder can take the same ladle of iron, and by pouring part of the metal into a mold that will chill or solidify it quickly, produce a fracture that will be close-grained in the one case and open in the other. This is just what the furnaceman does in making pig iron. One part of his tap, or cast of iron, may run so slowly from his furnace as to chill the metal before it reaches the pig beds, while another tap or

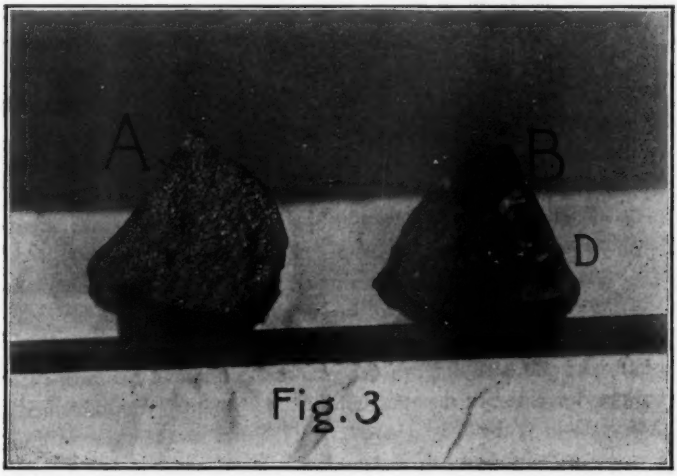


Fig. 3

cast may come so fast as to fill the pig beds so rapidly that it will take quite a while for the metal to solidify.

Again, one tap or cast at a furnace may give much hotter iron than another, and it is natural that the dull iron should cool faster than the hot, and, if both run at the same speed from the furnace down the long runners to the pig beds, will give the closer grained iron in the case of the duller metal. Surely the founder should perceive from this why the same kind of iron may have in one cast a close grain, and in another an open grain. As there are but few molders or founders who have ever had

the opportunity of witnessing a furnace cast, this explanation of its workings, combined with their own foundry experience, should assist many to realize why the fracture of pig metal is an unreliable guide to the iron's true grade.

There are those who are still sure to contend that open fractures mean a soft iron and a close-grained iron a hard one, and if different results are obtained, to charge such to changes in fuel, scrap iron, fluxes, blast, weather, etc. The writer has seelcted samples of pig shown in Figs. 1, 2 and 3 that are a fair representation of the whole cast or car of iron. If any of the old-school founders were asked to select a cast or car of iron to give soft castings, they would pick out iron such as sample "A," seen in Figs. 1 and 3, while if they desire to make strong or hard castings, they would select such irons as are represented by sample B, seen in Figs. 2 and 3. In fact, if some were asked to use such a cast or car of iron as that represented by B, they would claim that on account of its close grain and the blow-holes seen at D, the iron was hardly fit for sash-weights, let alone to think it of any value to make soft castings.

In order to convince the skeptical, or those not conversant with chemical analysis, or the effect of one metalloid upon another, that they are in error, the writer melted down about one hundred pounds of each of the grades A and B in his twin-shaft cupola described in a paper before the Pittsburg Foundrymen's Association, June 28th, 1897, and shown in the Association's journal, Vol. 3, Nos. 13 and 14, also The Foundry, for August, 1897. In melting these irons A and B, to make the castings seen in Figs. 1 and 2, and which range from one-eighth to two inches in thickness, all conditions were alike as near as it was possible to have them, so that if the open-grained iron, A, gave a hard casting, changes in fuel, scrap, blast, weather etc.—the old excuse—could not be offered as an explanation to befog the true cause. The sample of pig used and sections of the castings made from them, the writer has brought to this meeting, so that all may see them, and all are invited to take drillings from the specimens to report whether

their analyses agree with those presented in Table I, in which the letter A represents the analyses obtained from the pig and the castings seen in Fig. 1, while B gives those secured from Fig. 2.

TABLE I.

	Samples.	Silicon.	Sulphur.
A	Pig	1.25	.035
	Castings	1.15	.070
B	Pig	2.86	.040
	Castings	2.67	.060

The fracture seen in Fig. 3, being enlarged, will afford a better study of the difference existing between the grain of the pig, samples A and B. To the new-school founder, Table I is sufficient to define the results, or whether samples A and B would give the soft or hard iron upon being re-melted, but for the old school of founders, Tables II and III will best serve such ends. A study of these latter tables will show them that the pig, B, which would have been condemned by those wishing to make soft castings, gave by far the least contraction and chill, so much so that the test pieces, only one-eighth-inch thick, as seen at H, Fig. 2, are so soft as to be readily drilled, while at K, Fig. 1, made from sample A, broke a drill in trying to get one hole through the thin piece one-eighth-inch thick. In fact, we were foolish to try to touch it with a drill, as the metal was nearly all chilled or white in color, as can be seen in the sample brought here for your inspection. It is also to be said that all the other test pieces ranging from Nos. 2 to 12, that were made from the pig, sample A, were also much harder than those made from sample B. In measuring the depth of chill, pieces were broken off one end of the test bars, as seen at P, Fig. 1.

TABLE II.

RECORD OF TESTS TAKEN FROM IRON SEEN IN FIG. 1.

No. of bars.	Size of bars.	Contraction.	Deflection.	Strength. Lbs.	Chill.
1	⅛x1½	.293	.29	110	Nearly white.
2	¼x1½	.266	.25	320	¼ deep.
3	⅜x1½	.242	.21	550	¼ deep.
4	½x1½	.220	.18	860	3-16 deep.
5	⅝x1½	.200	.15	1,280	3-16 deep.
6	¾x1½	.182	.14	1,600	⅛ deep.
7	⅞x1½	.165	.12	2,240	⅛ deep.
8	1x1½	.150	.10	2,900	3-32 deep.
9	1¼x1¼	.148	.08	3,640	3-32 deep.

TABLE III.

RECORD OF TESTS TAKEN FROM IRON SEEN IN FIG. 2.

No. of bars.	Size of bars.	Contraction.	Deflection.	Strength. Lbs.	Chill.
1	⅛x1½	.178	.35	164	.03 deep.
2	¼x1½	.163	.030	344	.02 deep.
3	⅜x1½	.150	.24	530	.01 deep.
4	½x1½	.137	.18	920	H'dly percep'ble.
5	⅝x1½	.125	.14	1,208	No chill.
6	¾x1½	.112	.12	1,640	No chill.
7	⅞x1½	.101	.11	2,320	No chill.
8	1x1½	.92	.10	2,860	No chill.
9	1¼x1¼	88	.10	3,500	No chill.

Note.—Test bars Nos. 10 to 12, seen in Figs. 1 and 2, were not tested, owing to the machine being too small to break them.

This chill was obtained by causing the end of the test bars farthest from the gate to be formed by a wrought iron bar three-fourths by two inches wide. The twelve test bars were molded in green sand and poured from one gate. The same "temper" of sand was used for both flasks, and the iron was alike in fluidity at the time of pouring.

It is hoped that a study of this paper will help to convince those yet remaining aloof from utilizing chemical analyses, that the deceptive fracture of pig iron has and will continue to often mislead them in rightly locating the cause of trouble and losses in their efforts to obtain desired results from iron mixtures.

DISCUSSION.

Mr. Kreuzpointner: Mr. President, we have arrived in the history of our country at a stage of industrial development, where we have to blend theory and practice judiciously in our every day work, if we want to keep our present commanding industrial position for any length of time. We are now in the midst of a keen and fierce industrial warfare, and industrial warfare is as relentless in its efforts and effects, to crush its opponents, as is military warfare, notwithstanding it may be done without the flourishing of trumpets, or killing of each other in open combat. Hence it follows that the manufacturers and business men who, for the time being, are soldiers in the industrial army of the country, must be provided with the most modern weapons for offense and defense, if they want to succeed; if they do not want to be crowded against the wall, and find themselves at the wrong side of the ledger at the end of the year.

One of the weapons with which the manufacturer has to fight his battle for existence is his knowledge and judgment, with which to select the raw material used by him, in order to produce a superior article for the market, be that superiority in artistic design, strength, durability or adaptability for the purpose intended. The selection of the proper grade of pig iron is the foundryman's great concern, and Mr. West has pointed out very clearly in his paper that one of the principal weapons with which the foundryman fights the industrial battle of to-day, is antiquated and defective, in as much as the present method of selecting pig iron by fracture is defective and misleading.

How is the structure formed which we see on breaking a pig? A molten mass of iron in the blast furnace, cupola or ladle, is a combination of chemical elements, held in solution by the fluid mass of iron, as salt or sugar is held in solution by water. Each of these elements, when by itself, has a different melting point and point of cooling. Now it is a peculiarity of chemical elements that some of them are attracted to each other, thus forming a combination, more readily than other elements. This tendency

to mutual attraction we call affinity. As soon as the iron gets cold enough, crystals are forming and these crystals try to extract out of the surrounding fluid metal all the elements necessary to their growth. Thus the crystals grow as long as they have an opportunity to extract some of the substances surrounding them. Hence, if we cool iron quickly we prevent the crystals from growing any further, and they will have the size, therefore, the crystals had when stopped from growing further, and not the size representative of any particular chemical compound, generally speaking. This is clearly shown by the samples exhibited here by Mr. West, the pieces of small cross-section having a fine structure, because they cooled quickly and the crystals had no time to grow larger, while the larger sized sections have a coarse grain, because they had more time to grow, due to slow cooling. The fractures of the test bars exhibited by your Committee on "Standard Tests," show the same phenomenon. A couple of years ago I came across a very striking instance of the effect of time in cooling, on the size of the crystal structure of iron and steel. A large amount of the contents of an open hearth furnace escaped through the bottom of the furnace. The bottom was repaired and the metal left where it was until the furnace had to be torn down. Here was an opportunity for the escaped metal to cool very slowly. As a consequence the crystals in that mass of soft steel were of extraordinary size. I obtained a well formed crystal, which measured 1⅜ inches in length and ⅝ inch in width. I have still a piece of that metal with a crystal imbedded, measuring ⅝ inch. Ordinarily the crystals of such steel in the ingot measure a few hundredths of an inch.

Now, while such an instance as just mentioned is very rare, yet it furnishes proof of the importance and influence of time in cooling a molten mass of iron on the size of structure, irrespective of chemical composition. You can readily imagine the gradations in size of structure, due to time of cooling, between the crystal 1⅜ inches long, and the fine structure we might be able to obtain in the same metal by instantaneous cooling of the mass. For the same reason, an iron low in silicon may have as coarse, if not a

coarser fracture, than an iron high in silicon and graphitic carbon.

There is another property of cast iron, with which the foundrymen are much concerned, but which thus far has not received the attention it deserves. Cast iron is an alloy composed of iron and other substances. Now the melting point of alloys varies with the variation of the per cent. of constituents forming the alloy. Thus, for instance, wrought iron melts at 2912 degrees Fah., gray iron at 2280 degrees Fah., and white iron at 2075 degrees Fah. An alloy of 1 part tin and 25 parts lead melts at 558 degrees Fah., while an alloy of 6 parts tin and 1 part lead melts at 381 degrees Fah. The melting point of tin alone is 451 degrees Fah. and that of lead is 618 degrees Fah. Naturally an increase in the number of elements in an alloy and variations in the percentages of elements, will produce complications in the melting points of alloys. These complications are increased by the law of affinity, according to which certain elements will attract each other and combine with one another more readily than other elements. They will flock together like birds of a feather, as the saying is. It must be obvious that, during the formation of such complications, the rate of cooling again plays an important part.

But to fill the foundryman's cup of bitterness and perplexities to overflowing sometimes, and to make him scratch his head in wonderment as to what will come next, there is the phenomenon of segregation in alloys, and cast iron is very much bothered by this phenomenon. Iron, like water, has the ability to dissolve and hold in solution foreign substances when in a fluid state. But when a fluid mass of iron cools down to the point of solidification the foreign substances, held in solution while the iron was fluid, segregate out of the iron, one after another, the same as salt segregates out of the water whenever there was more salt dissolved in a hot brine than the water can hold when cold. Now the iron can hold more carbon, silicon, etc., chemically combined, when in a fluid state than it can hold in a solid state. Consequently, when a molten mass of cast iron freezes, so much of the foreign substances held in solution by the molten iron as cannot be held by the solidified iron, will be pushed out, or segregate out, until the

mixture reaches certain proportions. This mixture having reached such proportions of elements as is peculiar to cast iron will be the last portion in a casting to freeze, or solidify. This mixture in alloys, freezing last, is called the mother metal, in alloys of metals, and mother liquor in other mineral solutions, for cast and pig iron are nothing but mineral solutions after all.

According to Roberts-Austin and Jueptner von Johnstorff, the mother metal of cast iron is composed of 95.7 per cent. of iron and 4.3 per cent. of carbon. The mother metal of an alloy of copper and silver contains 28 per cent. of copper and 72 per cent. of silver. Whenever therefore, in an alloy an excess of elements is present, over and above the proportions necessary to form the mother metal, then this excess will separate, or freeze out, or segregate out of the molten mass and solidify before the mother metal freezes or solidifies. This is the reason why a plumber can make a wiped joint. If he would take a mixture of lead and tin, or whatever metals he uses, of such proportions as to just form the mother metal of a tin-lead alloy, he could not make a wiped joint, because his mixture would freeze, or solidify, under his hands so quickly, that no time would be left to wipe the joint, but having an excess of lead, this excess freezes first and continues freezing while the plumber is wiping his joint, until so much of the lead has frozen, or segregated out of the mixture, as to leave proper proportion of metals to form the mother metal. When that point is reached, the whole of the mixture freezes at once and altogether, without any further segregating out of the one or the other metal. Now this same action takes place in cast iron, or other alloys, and this segregating out for the excess of elements in alloys, over and above those proportions necessary to form the mother metal, or eutectic alloy, as scientists call it, is a disturbing factor of unknown influence in the brass and iron foundry. On account of this, cast iron has two cooling points instead of one. In other words, the excess of elements present, over and above the mother metal, solidify or freeze, first and at a higher temperature than the mother metal. For instance a mixture of cast iron with 98 per cent of iron and 2 per cent of carbon

will solidify at 2408 degrees Fah., but if the iron is given time enough to cool slowly for the segregating out of the excess of iron over and above 95.7 per cent of iron and 4.3 per cent of carbon, which is the mother metal of cast iron, then that iron will solidify at two different temperatures, viz., the excess at about 2408 degrees Fah. and at 2066 degrees Fah., which is the freezing point of the mother metal, or eutectic alloy of cast iron.*

According to Charpy, bronzes may sometimes have three, or even four freezing points.

The practical lesson for the foundryman from all this is, that if he knows he has the right mixture for a given purpose, to try and pour his iron at a sufficiently low temperature so as to prevent segregation as much as possible in large castings. Under unfavorable conditions such segregated castings, notwithstanding the chemical composition is all right, may be weak, because of the want of homogeniety of the structure. The casting may appear solid enough, but when a casting happened to solidify at two different temperatures, the structure, or grain cannot be uniform throughout the mass, and there is liability of lines of weakness running through the casting between the juncture of patches of coarser grain and finer grain.

The largest of the sections of the test pieces, exhibited by your test committee, are good object lessons of the influence of time of cooling on the size of the grain, and the formation of segregations in their worst form. We can also readily see that it is not always the chemical composition alone that secures a good, strong and sound casting. We can also imagine what possibilities there are in alloys in general, and cast iron in particular, for the formation of an endless variety of combinations and complications, due to this peculiarity of segregation in alloys of metals, and the greater the number of elements present, the greater the liability for complexities.

Mr. Groves: I certainly hope that the remarks as just made by Mr. Kreuzpointner will go on record, as I must say that I have never before heard so clear a statement of the subject under

* Roberts-Austin and Jueptner von Johnstorff.

discussion, and have listened to it with a great deal of pleasure, and trust that he may be persuaded to give us a paper on this subject later on."

Mr. Frank: The boat excursion will not take place, but arrangements have been made so that trolley cars will carry the party, and these will leave Market street and Fourth avenue at 1:30 p. m. sharp, and the committee hopes that the trip will be enjoyable."

The Secretary here read a letter from Mr. T. J. Best, of Montreal.

Warden King & Son, Craig Street Foundry,
Montreal, 15th May, 1899.

Mr. John A. Penton,
Secretary Foundrymen's Association, Pittsburg, Pa.:

Dear Sir—Will you kindly convey to the President, officers and members of the Association now convened my regrets at being absent from your grand convention.

I have been looking forward for a long time to the great profit and pleasure which would have been mine, if it were possible for me to be with you, but unfortunately our men are out on strike, and that precludes me from being on time at roll-call. Mrs. Best had arranged to go with me, and I have been looking forward with pleasure to this time, and have, in anticipation at least, been looking into the kindly faces of a number of gentlemen whom I have in the past years had the pleasure of speaking to and receiving instruction from.

I trust this will be the grandest of all your conventions, and wish you the greatest success and prosperity.

Sincerely yours,
T. J. BEST,
V. P. for Canada.

Mr. Becket: Mr. President, if in order, I would like to make a few remarks. The members of this convention have experienced the hospitality of the local foundrymen to a remarkable degree. It was three years ago in Philadelphia that we thought

a convention could never be more successful. This was duplicated at Detroit one year later. I was so unfortunate as not to be able to go to Cincinnati last year, but have been told of the very profitable and enjoyable time had there. Three years ago might properly be called the starting point of this Association, but it is to be noted that each succeeding convention is larger and better than the last, which tends to show the progress of the foundry industry, as is very evident by the assembling here of five or six hundred foundrymen of this country, and I think that a vote of thanks should be tendered the local foundrymen for the hospitality we have enjoyed, and I know that we will all cherish for many years the memory of the many acts of kindness we have received here. Therefore, I move that the thanks of this Association be tendered the foundrymen of Pittsburgh and vicinity, and same be spread upon the report of the proceedings.

Motion seconded and carried unanimously.

Moved and seconded that a vote of thanks be tendered the committee on entertainment of the ladies for their kind and thoughtful attention to the ladies.

Seconded and carried.

REPORT OF NOMINATING COMMITTEE.

To the President and Members of the American Foundrymen's Association:

Your Committee on Nominations take pleasure in presenting for your consideration the following names:

For President, Mr. J. S. Seaman, Seaman, Sleeth & Co., Pittsburgh, Pa.; for Secretary, Mr. John A. Penton, *The Foundry*, Detroit, Mich.; for Treasurer, Mr. Howard Evans, J. W. Paxson Co., Philadelphia, Pa.; for Vice-Presidents: New England States—Mr. A. W. Walker, Walker & Pratt Manufacturing Co., Boston, Mass.; Middle States—Dr. Richard Moldenke, McConway & Torley Co., Pittsburgh, Pa.; Southern States—Mr. J. P. Golden, Golden's Foundry & Machine Co., Columbus, Ga.; Central Western States—Mr. C. A. Bauer, Warder, Bushnell &

Giessner, Springfield, O.; Northwestern States—Mr. W. A. Jones, W. A. Jones Foundry & Machine Co., Chicago, Ill.; Southwestern States—Mr. W. S. Mosher, Mosher Manufacturing Co., Dallas, Texas; Pacific States—Mr. R. Chartrey, Vice-President Joshua Hendy Machine Works, San Francisco, Cal.; Canada—Mr. Joseph Best, Warden King & Son, Montreal, P. Q.

(Signed) W. A. JONES,
Chairman;
RICHARD MOLDENKE,
J. S. STIRLING,
J. P. GOLDEN,
E. G. LYON.

Mr. Seaman: While I appreciate the honor, and it is a very great honor, that you wish to put upon me, still I think there are a great many men in this convention that are much more able to fill this position than I, and as such I think they should be selected for the place. I would therefore beg to be excused.

Mr. Becket: The gentleman's modesty bespeaks his merit, and I therefore move that the recommendations of the committee be adopted, and that Mr. I. W. Frank cast a ballot for the election of the gentlemen as nominated.

Seconded and carried.

Mr. Penton: During the convention in Cincinnati a committee was appointed to organize the National Founders' Association, which association has grown to be very powerful. This is the offspring of the American Foundrymen's Association, and our members paid the expense of starting it. During the last few months labor troubles have been very frequent, and as I have been honored with the selection of Secretary, it has taken a great deal of my time, and I have been unable to give the American Foundrymen's Association the attention it probably should have had.

For this, and for personal reasons, I am not at all sure that I can accept the position for another term. While appreciating very highly the apparent confidence reposed in me, yet still, as I have indicated to a large number of those present, I feel that it

would not be justice to the Association or myself either to accept the Secretaryship for the coming year.

Mr. Bell: Gentlemen of the convention, I have the honor to present to you Mr. Seaman, who will serve you as President for the coming year, and I trust that the Association may go on to still greater success than it has attained in the past.

Mr. Seaman: Gentlemen, I will say that I have very great hesitancy in accepting this office. The American Foundrymen's Association is of an educational nature, and there is considerable labor involved in conducting its affairs. I am not a general foundryman, but what might be caled a specialist in this line. While the present convention has been a very large one, and the foundrymen of Pittsburgh are very proud of the number attending, it will be my policy to endeavor to increase the interest and attendance on these meetings from time to time, but I will say that I think you have made a mistake in your selection. I remember once of a very big casting being made, the mold was prepared and everything put in readiness for pouring, but when the mold was half full the metal run out, all because a clamp was not fastened; and I feel that the present position I find myself in is a comparable instance, and I hope that I will have your assistance at all times.

Mr. Moldenke: I think I voice the sentiment of the entire membership of this Association when I place in nomination for honorary membership Mr. Bell's name.

Mr. Becket: As an amendment, I move that this motion be made to include a vote of thanks to Mr. Bell for the work that he has done as President of this Association.

The motion as amended was seconded and carried unanimously.

Mr. Frank: In regard to the remarks made by Mr. Penton with reference to the National Founders' Association, I can bear him out fully in what he has said and know that the other association requires very much of his time, but I think that it can

be arranged so that he can serve as Secretary for both Associations.

Mr. Penton: Mr. Frank is fully aware of my position in the National Founders' Association, and if the matter can be left in this slightly unsettled position, I will be willing to serve until the question is finally settled.

Motion made and seconded that the convention adjourn *sine die.*

Carried.

DIRECTORY OF THOSE WHO ATTENDED THE FOURTH ANNUAL CONVENTION OF THE AMERICAN FOUNDRYMEN'S ASSOCIATION, PITTSBURG, MAY 16-19, 1899.

C. S. Bell, C. S. Bell & Co., Hillsboro, O.
John A. Penton, "The Foundry," Detroit, Mich.
Wm. Yagle, Wm. Yagle & Co., Pittsburg.
J. T. Seaman, Seaman, Sleeth & Co., Pittsburg.
F. H. Zimmers, Union Foundry & Machine Co., Pittsburg, S. S.
Isaac W. Frank, Frank-Kneeland Mach. Co., Pittsburg.
Phillips Mathes, Brittan & Mathes Co., Carnegie, Pa.
Dr. R. G. G. Moldenke, McConway & Torley Co., Pittsburg.
S. D. Sleeth, Westinghouse Air Brake Co., Wilmerding.
Robert Taylor, Taylor, Wilson & Co., Lim., Allegheny.
Dr. W. B. Phillips, "American Manufacturer," Pittsburg.
T. E. Malone, J. S. McCormick Co., Pittsburg.
Samuel Hay, Whiting Fdy. Equip. Co., Pittsburg.
Howard M. Hooker, Rogers, Brown & Warner, Pittsburg.
E. P. Botsford, Pitts, Malleable Iron Co., Pittsburg.
George Rollings, Pitts. Malleable Iron Co., Pittsburg.
R. Wise, Keystone Coal & C. Co., Pittsburg.
James Kelly, A. H. Childs, Pittsburg.
E. A. Kebler, Mathew Addy & Co., Pittsburg.
J. S. McCormick, J. S. McCormick Co., Pittsburg.
W. T. Mobberley, Taylor, Wilson & Co., Allegheny.
Robert A. Walker, "Iron Age," Pittsburg.
S. H. Stupakoff, Union Switch & Sig. Co., Swissvale, Pa.
S. T. Johnston, The S. Obermayer Co., Chicago, Ill.
C. L. Doyle, H. C. Frick Coke Co., Pittsburg.
Dr. K. F. Stahl, General Chemical Co., Pittsburg.
N. P. Hyndman, Washington Coal & C. Co., Pittsburg.
Victor Beutner, Julius Kennedy, Pittsburg.
Edward Maher, Maher & Flockhart, Newark, N. J.
H. S. Vrooman, Chicago, Ill.
R. C. Barr, Cleveland & Barr, Chicago, Ill.
John W. Burr, Burr & Houston, Brooklyn, N. Y.

Robert Blythe, Walker & Pratt Mfg. Co., Watertown, Mass.
Chas. B. Seaman, Seaman, Sleeth & Co., Pittsburg.
Jos. S. Seaman, Jr., Seaman, Sleeth & Co., Pittsburg.
C. W. Friend, Clinton Iron & Steel Co., Pittsburg.
Eli Millett, Millett Core Oven Co., Sppringfield, Mass.
Oliver Wylie, Wm. Yagle & Co., Pittsburg.
Wm. Altsman, Jas. Collard & Co., Pittsburg.
E. W. Anthony, Smith, Anthony & Co., Boston, Mass.
J. S. MacDonald, Westinghouse E. Co., Pittsburg.
Benj. D. Fuller, Westinghouse E. Co., Pittsburg.
J. H. Johnston, Taylor, Wilson & Co., Pittsburg.
W. J. Keep, Michigan Stove Co., Detroit, Mich.
Geo. H. Lincoln, Geo. H. Lincoln & Co., Boston, Mass.
John Magee, Magee Furnace Co., Boston, Mass.
I. W. Winchester, Magee Furnace Co., Boston, Mass.
J. C. Slocum, P. H. and F. M. Roots Co., Connersville, Ind.
W. Fitzpatrick, S. Obermayer Co., Cincinnati, O.
Alex. Taylor, Westinghouse E. Co., Pittsburg.
J. J. Burgen, Lane Mnfg. Co., Montpelier, Vt.
L. S. Brown, Springfield Facing Co., Springfield, Mass.
Alva Carpenter, A. Car'nter & Sons Fdry Co., Providence, R. I.
F. B. Farnsworth, McLagon Foundry Co., New Haven, Conn.
Victor Swenson, Condor Foundry Co., Boston, Mass.
C. W. Friend, Clinton Iron & Steel Co., Pittsburg.
T. W. Friend, Clinton Iron & Steel Co., Pittsburg.
E. B. Pierce, Wheeler Foundry Co., Worcester, Mass.
C. J. Langdon, Fulton Foundry Co., Cleveland, O.
John F. Mills, Carpenter Bros., Worcester, N. Y.
Willis Brown, Walker Foundry Co., Erie, Pa.
J. D. Smith, J. D. Smith Fdry. Sup. Co., Cincinnati, O.
J. G. Sadlier, Springfield Fdry. Co., Springfield, O.
W. A. Jones, W. A. Jones F. & M. Co., Chicago.
F. S. Cadwell, Hill & Griffith Co., Cincinnati, O.
F. H. Irwin, Elliot Car Co., Gadsden, Ala.
John Hill, Hill & Griffith, Cincinnati, O.
J. P. Gardner, Cincinnati, O.

J. R. Stoner, J. R. Homer Co., Galion, O.
R. Wise, Keystone Coal & C. Co., Pittsburg.
M. F. Richardson, Ohio Cultivator Co., Bellevue, O.
E. M. Drummond, Drummond Mnfg. Co., Louisville, Ky.
T. W. Sheriffs, Sheriffs Mnfg. Co., Milwaukee, Wis.
D. B. Hyde, Safety Emery Wheel Co., Springfield, O.
R. J. Scott, Struthers, Wells & Co., Warren, Pa.
F. C. Mosedale, M. A. Hanna & Co., Buffalo, N. Y.
H. M. Wilson, Taylor, Wilson & Co., Allegheny.
J. H. B. Bryan, Snow Steam Pump Co., Buffalo, N. Y.
C. J. Wolff, L. Wolff Mnfg. Co., Chicago.
J. R. Russel, Russel Wheel & Foundry Co., Detroit, Mich.
C. W. Russell, Russel Wheel & Foundry Co., Detroit, Mich.
J. C. Ford, Springlake Iron Co., Freeport, Mich.
E. S. Reid, Whiting F. Equip. Co., Chicago.
E. S. Walker, J. I. Case Threshing Machine Co., Racine, Wis.
W. W. Cheney, S. Cheney & Son, Manlius, N. Y.
John A. Meighan, Dawson Bro. & Meighan, Pittsburg.
R. M. Dyer, The Aermotor Co., Chicago.
O. T. Stantial, Ill. Malleable Iron Co., Chicago.
J. R. Steneck, Ill. Malleable Iron Co., Chicago.
John W. Diven, Diven Bros. & Co., Baltimore, Md.
W. T. White, J. D. Smith Foundry Supp. Co., Cincinnati, O.
Andrew McDuff, Stillwell, Bierce & Co., Dayton, O.
Henry Miller, Stillwell-Bierce Co., Dayton, O.
Victor E. Knecht, Phoenix Iron Co., Cincinnati, O.
R. S. Buch, A. Buch Sons, Elizabethtown, Pa.
J. H. Hillman, J. H. Hillman Co., Pittsburg.
J. H. Hillman, Jr., J. H. Hillman Co., Pittsburg.
B. E. Eagan, H. E. Pridmore, Boston, Mass.
Jas. S. Stirling, Harlan & Hollingsworth Co., Wilmington, Del.
Millard F. Carr, J. W. Paxson & Co., Philadelphia.
W. J. Early, W. J. Early & Sons, Pittsburg.
W. A. Early, W. J. Early & Sons, Pittsburg.
Jas. S. Early, W. J. Early & Sons, Pittsburg.
Jno. N. Early, W. J. Early & Sons, Pittsburg.

B. T. Bacon, Pickands-Mather Co., Chicago.
W. F. Prince, H. R. Worthington Hyd. Co., Elizabethport, N. J.
John Logan, Jones & Laughlins, Lim., Pittsburg.
Jno. Morcum, Colorado Iron Works, Denver, Col.
A. J. Cordingly, Queen City Foundry Co., Denver, Col.
A. G. Sutherland, Kansas Iron & Wire Co., Kansas City, Mo.
E. Kneeland, Frank-Kneeland Mach Co., Pittsburg.
W. W. Sly, Cleveland.
W. P. Warren, Jr., Tuttle & Warren Co., Troy, N. Y.
Fr. Cavanaugh, Roberts, Winter & Co., Quaker'tn, Pa.
Sirard Babbit, Port Royal Coal & C. Co., Pittsburg.
W. W. McMillan, Damascus Bronze Co., Pittsburg.
W. B. Sterritt, Sterritt & Thomas, Pittsburg.
G .F. Eldridge, C. R. Baird & Co., Philadelphia.
J. W. Friend, Clinton Iron & Steel Co., Pittsburg.
Chas. W. Haas, Stillwell B. & S. Vaile Co., Dayton, O.
J. R. Cullingworth, Robt. Witherill & Co., Chester, Pa.
J. M. Stoeva, Robt. Witherill & Co., Chester, Pa.
J. E. Lyon, Brown & Sharpe Mnfg. Co., Providence, R. I.
Bartlett M. Shaw, Walker & Pratt Mnfg. Co., Watertown, Mass.
Wm. H. Switzer, Superior Foundry Co., Littleton, N. Y.
M. A. Moran, Carnegie Steel Co., Pittsburg.
Jno. McClaren, Phillips & McClaren, Pittsburg.
Geo. Mesta, Mesta Machine Co., Pittsburg.
G. M. Sharp, M. T. Sharp & Son, Steubenville, O.
W. H. Rea, Mesta Machine Co., Pittsburg.
J. H. Becker, Clinton Iron & Steel Co., Pittsburg.
S. B. Robinson, Robinson Mach. Co., Mononghahela City, Pa.
Jesse Cornelius, Hecla Iron Works, Brooklyn, N. Y.
Robt. B. Lean, Crescent Fdry. & Con. Co., Allegheny.
J. P. Golden, Golden F. & M. Co., Columbus, Ga.
A. W. Walker, Walker & Pratt Mnfg. Co., Boston, Mass.
D. J. Thomas, Sterritt & Thomas, Pittsburg.
F. A. Goodrich, F. A. Goodrich & Co., Detroit, Mich.
L. W. Frazier, Keystone Coal & C. Co., Pittsburg.

F. H. Watt, Watt Mining Car W. Co., Barnesville, Ind.
Alex. Jarecki, Jarecki Mnfg. Co., Erie, Pa.
H. S. Bell, Dodge Mfg. Co., Mishawaka, Ind.
C. M. Collins, Dodge Mnfg. Co., Mishawaka, Ind.
W. C. Swift, H. E. Pridmore, Chicago, Ill.
Alex. W. Slocum, Penna. Car Wheel Co., Pittsburg.
Chas. V. Slocum, Penna. Car Wheel Co., Pittsburg.
W. H. Coffin, T. P. Kelly & Co., New York.
Jos. A. Kelly, Reliance Steel Casting Co., Pittsburg.
Chas. Bailey, Reliance Steel Casting Co., Pittsburg.
Samuel McKees, Lorain Steel Co., Lorain, O.
F. E. Mesta, Mesta Mach. Co., Pittsburg.
C. J. Mesta, Mesta Mach. Co., Pittsburg.
Edwin H. Oswuld, Benedict & Burnham M. Co., W'terb'y, Conn.
W. T. McCutcheon, Safety Emery Wheel Co., Springfield, O.
John H. Torlley, Kenzie & Jones Mnfg. Co., Pittsburg.
John H. Noble, Kenzie & Jones Mnfg. Co., Pittsburg.
A. H. Childs, A. H. Childs & Co., Pittsburg.
D. H. Delamater, The Sperman Iron Co., Sharpsburg, Pa.
E. M. Gross, Keystone Coal & C. Co., Pittsburg.
E. A. Uehling, Pittsburg.
G. H. Ginther, Pittsburg.
Edward Thomas, The James E. Thomas Co., Newark, O.
Harry S. Hill, Taylor, Wilson & Co., Ltd., Allegheny.
F. W. Bauer, Warder, Bushnell & Glessner Co., Springfield, O.
W. A. Noble, Aultman-Miller Co., Akron, O.
James Hay, Aultman-Miller Co., Akron, O.
L. J. Gray, Miller, Wagoner, Fieser & Co., Columbus, O.
C. Birmingham, Pittsburg Lamp & Brass Co., Pittsburg.
James J. Kelly, M. Kelly & Son, Pittsburg.
S. Groves, Westinghouse Mach. Co., E. Pittsburg.
P. Kreuzpointner, Penn. R. R. Testing Dept., Pittsburg.
Nicholas Kelly, N. Kelly & Son, Pittsburg, S. S.
J. D. Cullinan, McConway Torley Co., Pittsburg.
John Pfeil, McConway Torley Co., Pittsburg.
J. M. Ryan, McConway Torley Co., Pittsburg.

S. M. Rogers, Am. Steel & Wire Co., Pittsburg.
F. E. Gordon, Ohio Sand Co., Conneaut, O.
Wm. T. Bradberry, Anshutz-Bradberry, Allegheny.
H. T. Irwin, Rosedale Foundry Co., Pittsburg.
James Boyle, Kinzer & Jones Mnfg. Co., Pittsburg.
R. F. Barker, Pittsburg.
Thos. D. West, T. D. West Foundry Co., Sharpsville, Pa.
C. W. Jones, Rosedale Foundry, Allegheny.
Frank Anshutz, Anshutz-Bradberry Co., Allegheny.
J. C. Reed, Standard Mnfg. Co., Pittsburg.
W. E. McGraw, "Iron Trade Review," Chicago and Cleveland.
G. H. Gardner, "Iron Trade Review," Chicago and Cleveland.
A. J. Miller, Jr., Whitehead Bros. Co., New York.
D. S. Evans, Rosedale Foundry, Pittsburg.
W. D. McKeefrey, McKeefrey & Co., Leetonia, O.
C. W. McCleery, McCleery & Co., Leetonia, O.
B. B. Luty, "Iron Trade Review," Pittsburg.
W. Hanson, Penna. Iron Works, Philadelphia.
E. E. Hanna, Gates Iron Works, Chicago, Ill.
Stanley G. Flagg, Jr., Stanley G. Flagg Co., Philadelphia.
Jas. A. Beckett, W. A. Wood M. & R. Co., Hoosick Falls, N. Y.
H. C. Shaw, Lewis Foundry and Machine Co., Pittsburg.
Enrique Tonceda, W. A. Wood M. & R. Co., Hoosick Falls, N. Y.
A. G. Hubbard, Wheeling Mold & Fdry. Co., Wheeling, W. Va
C. A. Shanklin, Wheeling Mold & Fdry. Co., Wheeling, W. Va.
W. Strangward, Forest City Foundry Mnfg. Co., Cleveland.
D. G. Moore, Saml. L. Moore & Sons Co., Elizabeth, N. J.
T. I. Rankin, Abram Cox Stove Co., Philadelphia.
W. G. Harker, Knott, Harker & Co., Beaver Falls, Pa.
A. H. Blackburn, Fuel Economizer Co., Matteawan, N. Y
Harris Tabor, Tabor Mnfg. Co., Elizabeth, N. J.
T. H. Assberry, The Enterprise Mnfg. Co., Philadelphia.
Amos Walder, Genesee Foundry Co., Rochester, N. Y.
J. M. Atcheson, H. C. Frick Coke Co., Pittsburg.
Geo. H. Barbour, Michigan Stove Co., Detroit, Mich.

J. M. Sloan, Redstone Oil C. & Ck. Co., Pittsburg.
L. H. Hiller, J. H. Hillman & Co., Pittsburg.
Andrew C. Daft, Reed F. Blair & Co., Pittsburg.
C. A. Hamilton, Deane Steam Pump Co., Holyoke, Mass.
Richard Garlick, The Lloyd Booth Co., Youngstown, O.
Davis Carlin, The Carlin Mnfg. Co., Pittsburg.
W. S. Elkins, Pennsylvania Car Wheel Co., Pittsburg.
George S. Fisher, Fisher Fdry. & Machine Co., Pittsburg.
W. A. Herron, Lewis Fdry. & Machine Co., Pittsburg, S. S.
W. J. Phillips, Phillips & McClaren Co., Pittsburg.
George E. Brush, Brush & Stevens, Pittsburg.
John A. Stevens, Brush & Stevens, Pittsburg.
F. M. Smythe, Lorain Foundry Co., Lorain, O.
Geo. P. Bliss, Brittain & Mathes Co., Pittsburg.
H. A. Strauss, The Lloyd Booth Co., Youngstown, O.
Geo. S. Houghton, H. C. Frick & Co., Pittsburg.
Harry Stephens, Brush & Stephens, Pittsburg.
C. P. Kruth, McConway Torley Co., Pittsburg.
L. A. Anshutz, Anshutz-Bradberry Co., Pittsburg.
W. D. Burt, Enterprise Foundry Co., Allegheny.
Robert Bentley, The Ohio Iron and Steel Co., Lowellville, O.
T. E. Klauss, Kinzer & Jones Mnfg. Co., Pittsburg.
Donald Fraser, Northwestern Nail & Iron Co., Milwaukee, Wis.
E. L. Fitzmaurice, J. D. Smith Fdy. Supply Co., Cincinnati, O.
W. J. McCormick, Riter & Conley Co., Pittsburg.
A. G. Barnett, Jr., A. Garrison & Co., Pittsburg.
A. W. Cadman, A. W Cadman Co., Pittsburg.
J. D. Ford, Porter Foundry and Machine Co., Allegheny, Pa.
James Craig, Riter & Conley Co., Pittsburg.
Chas. S. Perrine, Crafton, Pa.
C. A. Sercomb, Milwaukee, Wis.
Chas. O. Ott, Lorain Steel Co., Johnstown, Pa.
A. E. Kornfeld, Engineering News, New York.
A. I. Findley, Iron Trade Review, Cleveland, O.
A. E. Doak, Whitehead Bros., New York.
C. B. Crook, Lidgerwood Mnfg. Co., New York.

John Weink, Walworth Run Foundry Co., Cleveland, O.
C. S. Little, C. S. Little, Johnstown, Pa.
J. M. Tate, Jr., Tate, Jones & Co., Pittsburg.
E. S. Dawes, Dawes & Myler, N. Brighton, Pa.
W. A. Myler, Dawes & Myler, N. Brighton, Pa.
T. A. Barker, A. Bradley & Co., Pittsburg.
H. S. Graff, Graff & Co., Pittsburg.
J. L. Hukill, Fort Pitt Bronze Co., Pittsburg.
J. C. Porter, Porter Fdry. & Machine Co., Allgeheny, Pa.
J. V. Smith, Porter Fdry. & Machine Co., Allegheny, Pa.
F. A. B. Ammon, A. Bradley & Co., Pittsburg.
Chas. McVay, A. Bradley & Co., Pittsburg.
John C. Bash, Baldwin & Graham, Pittsburg.
Jos. Bell, Jos. Bell & Co., Wheeling, W. Va.
A. B. Waggoner, Red Stone Oil and Coke Co., Pittsburg.
F. A. Neale, Carnegie Steel Co., Pittsburg.
H. J. Lindsay, Carnegie Steel Co., Pittsburg.
Hugh McCully, Jones & Laughlin, Pittsburg.
Hugh Kennedy, Jones & Laughlin, Pittsburg.
F. H. McClure, Robinson Rea Co., Pittsburg.
A. P. Patterson, S. K. Brown & Co., Pittsburg.
John Bindley, Bindley Hardware Co., Pittsburg.
G. A. Hogg, Totten & Hogg Iron & Steel Co., Pittsburg.
H. J. Taylor, Taylor, Wilson & Co., Allegheny.
P. V. Luty, Iron Trade Review, Pittsburg.
W. W. Hearne, Matthew Addy & Co., Cincinnati, O.
Alex. Wilson, Rogers, Brown & Warner, Pittsburg.
Wm. G. Miner, E. A. Kebler, Pittsburg.
L. K. Brown, L. K. Brown & Co., Zanesville, O.
Jas. L. Morral, Seaman, Sleeth & Co., Pittsburg.
J. H. Hammond, Seaman, Sleeth & Co., Pittsburg.
C. Wike, Hall Steam Pump Co., Allegheny.
W. R. Yagle, Wm. Yagle Co., Pittsburg.
R. S. Bosworth, Hugh Waddaams Co., New York and Boston.
J. W. Conway, Pratt & Cady Co., Hartford, Conn.

Eli Millett, Millett Core Oven Co., Springfield, Mass.
Clar. H. Joslyn, Merrimac Foundry Co., Lawrence, Mass.
Michael Donlon, L. H. Goodnow Foundry Co., Fitchburg, Mass.
W. H. Stafford, Bausch & H. M. Tool Co., Springfield, Mass.
J. A. Stone, Riverside Foundry Co., Cleveland, O.
Benton Orbison, Frazer & Chalmers, Chicago.
C. E. Hoit, Louis Insurance Foundry, Chicago.
H. Gossiger, Eureka Foundry Co., Cincinnati.
Robt. S. Osworth, Eureka Foundry Co., Cincinnati.
Lincoln Haney, Globe Foundry, Cincinnati.
E. K. Rundle, Rundle-Spence Mnfg Co., Milwaukee.
O. Wilcox, Taylor, Wilson & Co., Allegheny.
E. U. Scovill, E. U. Scovill Foundry Co., M'nlins, N. Y.
Geo. W. Cope, Metal Worker and Iron Age, Chicago.
John C. Meyers, Totten & Hogg Iron & Steel Co., Pittsburg.
Jas. Denham, Taplin, Rice & Co., Akron, O.
J. A. Findley, Philadelphia R. Machine Co., Philadelphia.
C. M. Nichols, Benj. Nichols & Sons, Jamestown, N. Y.
S. Watt, Watt Mining Car Wheel Co., Barnesville, O.
A. Eadie, Jas. Simpson & Co., London, Eng.
Geo. A. Moke, Gen. Chemical Co., Pittsburg.
Jas. C. Alley, C. G. Paison & Co., Boston, Mass.
J. D. Armrod, Donaldson Iron Co., Emaus, Pa.
C. S. McCleery, McKeefrey C. Co., Leetonia, O.
Ed. Caffey, Keystone Coal and Coke Co., Pittsburg.
Wm. Seabright, Spaire Baggs, Martin's Ferry, O.
C. W. Baker, Editor Engineering News, New York.
A. H. McCall, Erie Foundry Co., Rochester, N. Y.
H. A. Uulf, Union Iron Works, San Francisco.
G. A. Hogg, Totten & Hogg Iron & Steel Co., Pittsburg.
W. A. Beckert, Totten & Hogg Iron & Steel Co., Pittsburg.
W. W. Wilkinson, Wikoff, Seamon & Bennet, Pittsburg.
H. P. Spilker, Sterritt & Thomas, Pittsburg.
Chas. Baur, Sterritt & Thomas, Pittsburg.
W. H. Harris, Standard Radiator Co., Buffalo, N. Y.

W. J. Naeser, Wm. Yagle C. Co., Pittsburg.
A. Snyder, Wilson, Snyder & Co., Pittsburg.
C. L. Schmick, Cherry Valley Iron Co., Leetonia, O.
Ed McFarland, Matthew Addy & Co., Cincinnati.
F. duP. Thompson, C. G. Hussey & Co., Pittsburg.
F. W. Gould, Union Malleable Iron Co., Moline, Ill.
N. B. Richardsdon, Monongahela House, Pittsburg.
F. A. Williams, Youngstown, F. & M. Co., Youngstown, O.
C. C. Smith, Union Steel Casting Co., Pittsburg.
C. C. Ross, Geo A. McLean & Co., Pittsburg.
H. E. Nicholls, Monongahela, Pittsburg.
T. G. Stem, S. P. Haller, Pittsburg.
W. Speer, Reliance Casting Co., Pittsburg.
G. H. Marshall, Marshall Bros., Pittsburg.
J. E. Williams, Springfield Foundry Co., Pittsburg.
W. P. Bowney, Yough. River Coal Co., Erie, Pa.
S. V. Hunnings, Pittsburg Locomotive Works, Allegheny.
W. H. Simmonds, W. H. Simmonds & Co., Pittsburg.
J. T. Rowley, Bridgewater Steel Co., Bridgewater, Pa.
W. B. Bishop, Bridgewater Steel Co., Bridgewater, Pa.
D. W. Loomis, S. H. Dickson, Pittsburg.
John O. Little, P. F. Smith Litho. Co., Pittsburg.
R. J. Wilson, Wilson, Snyder & Co., Pittsburg.
J. V. Patton, Hastings Steel Cast. Co., W. Bridgewater, Pa.
C. T. Holbrook, Davis Coal and Coke Co., Philadelphia.
F. B. Lott, Davis Coal and Coke Co., Philadelphia.
F. A. Humphrey, Norton Emery Wheel Co., Worcester, Mass.
R. F. Blair, R. F. Blair & Co., Pittsburg.
Chas. G. McKee, R. F. Blair & Co., Pittsburg.
Wm. H. Kelly, Buckeye Engine Co., Salem, O.
R. L. Oberholser, Pittsburg Forge and Iron Co., Pittsburg.
Alonzo Kim, Mesta Machine Co., Pittsburg.
A. K. Beckwith, Estate of P. D. Beckwith, Dowagiac, Mich.
R. H. Boggis, Taylor & Boggis Foundry Co., Cleveland, O.
Taylor H. Boggis, Taylor & Boggis Foundry Co., Cleveland, O.

R. M. Wallingford, Jr., Thos. A. Mack, Cincinnati, O.
H. G. Lloyd, Eagle Emery and Corundum Wheel Co., Chicago.
Frank D. Kinser, Mahoning Fdry. & Mach. Co., Youngstown, O.
W. S. Pattin, Pattin Bros., Marietta, O.
U. E. Kanavel, E. M. Myers, Zanesville, O.
Isaac C. Capron, Ashland Emery Mills, Perth Amboy, N. J.
Gust Bowman, Jones & Laughlin, Pittsburg.
W. E. Tremely, Jones & Laughlin, Pittsburg.
J. B. Munslow, Taylor & Wilson Co., Ltd., Allegheny.
George Leas, Crescent Steel Co., Pittsburg.
H. Wilson, Pennsylvania Car Wheel Co., Allegheny.
David Justice, A. Speer & Sons, Pittsburg.
Richard Muse, Thos. Marshall Foundry Co., Pittsburg.
J. R. Backofen, Westinghouse Electric Mnfg. Co., Pittsburg.
Thos. Andrew, Thos. Marshall Foundry Co., Pittsburg.
Peter Hartmann, Hinzer & Jones Mnfg. Co., Pittsburg.
William Veltt, Pittsburg Foundry and Machine Co., Pittsburg.
J. H. McKinnie, Riverside Foundry, Pittsburg.
F. J. Hepp, Westinghouse Electric Mnfg. Co., Pittsburg.
A. F. Koones, Webster Camp & Lane Machine Co., Akron, O.
C. W. Watson, Vulcan Iron, Ltd., New Castle, Pa.
H. C. Wiskittel, A. Wiskittel & Son, Baltimore, Md.
W. A. McElroy, Riverside Iron Works, Wheeling, W. Va.
W. S. McElroy, Riverside Iron Works, Wheeling, W. Va.
Jas. Powell, Wm. Powell & Co., Cincinnati, O.
Wm. Porteous, Wm. Powell & Co., Cincinnati, O.
T. H. Gartland, Gartland Foundry Co., Cleveland, O.
J. A. Oberholmen, C. F. Thauwald Co., Cincinnati, O.
Henry S. Schwargenberg, R. B. Seidel, Cleveland, O.
W A.. Bole, Westinghouse Machine Co., Pittsburg.
G. B. Morrow, Braeburn Steel Co., Braeburn, Pa.
J. S. Graham, Baldwin & Graham, Pittsburg.
Wm. N. Gartside, Diamond Clamp & Flask Co., Richmond, Ind.
Thos. McKenna, A. & T. McKenna, Pittsburg.
J. H. Bloger, Bloger Bros., Pittsburg.
Thos. A. Orr, Robinson & Orr, Pittsburg.

S. R. Baldwin, Baldwin & Graham, New Castle, Pa.
Chas. H. Bradley, A. Bradley & Co., Pittsburg.
Orlando Miller, Westinghouse Air Brake, Pittsburg.
Richard Yagle, Wm. Yagle & Co., Pittsburg.
A. M. Spies, Sheffield, Eng.
Robert Schott, Seebohm & Dieckstabl, Sheffield, Eng.
W. J. Morton, Ohio Sand Co., Conneaut, O.
W. L. Scaife, Scaife Foundry and Machine Co., Pittsburg.
W. A. Merritt, Lorain Steel Co., Johnstown, Pa.
Bayard Phillips, Phillips & McClaren, Pittsburg.
S. H. Steavans, Kinzer & Jones, Pittsburg.
James Dickson, Brittan & Matthes, Pittsburg.
Albert W. Smith, Case School, Cleveland, O.
R. C. Hills, Colorado Fuel and Iron Co., Denver, Col.
John A. Coyle, Mesta Machine Co., Pittsburg.
S. C. Mason, McConway-Torley Co., Pittsburg.
E. M. Grove, McConway Torley Co., Pittsburg.
C. L. Baldwin, New Castle Engineering Co., New Castle, Pa.
J. M. Botsford, Pittsburg Malleable Iron Co., Pittsburg.
A. R. Riley, Pittsburg Malleable Iron Co., Pittsburg.
Emil Swenson, Keystone Bridge Works, Pittsburg.
C. S. Rea, Mesta Machine Co., Pitstburg.
F. E. Russell, F. T. Aschman & Co., Pittsburg.
W. G. Lee, Specialty Mnfg. Co., Allegheny.
H. G. Dravo, H. G. Dravo Iron and Steel Co, Allegheny.
C. M. Miller, Gartland & Co., Cleveland.
W. D. Berry, Fort Pitt Bronze Co., Allegheny.
L. F. Denverman, D. W. Van Duzen Co., Cincinnati, O.
J. H. Wilson, Wilson Snyder Foundry Co., Pittsburg.

PROCEEDINGS OF THE PHILADELPHIA FOUNDRYMEN'S ASSOCIATION.

At the meeting of this association, held May 3d, Edgar S. Cook, president of the Warwick Iron Co., Pottstown, Pa., read the following paper on "Blast Furnace and Cupola Practice:"

BLAST FURNACE AND CUPOLA PRACTICE.

The increase of the daily product of the modern blast furnace has called the attention of managers to the necessity of improved methods for casting and handling the large tonnage of iron. Not many, years ago, all the pig iron made was cast in pig beds molded in sand. Even with moderate products, there has always been more or less trouble in securing men to remove the iron from the cast-house. Few men, comparatively, have the physical strength, or having the strength, care to perform this exhausting labor, day after day, Sundays and legal holidays included. Blast furnace work is absolutely continuous. We have no holidays, and if the men to fill certain positions are not at hand, they must be replaced or the furnace stopped. Frequent stoppages are costly and disastrous.

The difficulty is not alone with the removal of the iron from the beds. After the iron is tapped from the furnace and distributed into the twenty or thirty beds, each "pig" must be separated from its "sow" and the "sow" running the length of each bed, must be broken into lengths corresponding approximately with that of the pig. This work is usually done when the iron has become sufficiently solid to bear the weight of a man, and not bleed or run when separated. This is hot and exhausting work, especially in the summer months, and not unfrequently is the source of the greatest anxiety to the manager. Many men cannot withstand the burning heat and succumb, thus discouraging others, who are only too ready to avail themselves of any excuse to escape the trying ordeal. The pigs must be separated from the sow and the sow broken, otherwise the iron cannot be removed and the beds molded for succeeding casts—the casts following one another every four or five hours.

Various mechanical appliances have been proposed from time to time, but one objection or another prevented their adoption. Furnaces connected with steel works substituted for the sand beds, iron molds, or chills, as they are termed. These chills obviated the necessity of molding in sand, thus economizing in labor and saving time, and thereby increasing the capacity of the cast-house, but their use did not overcome the necessity of breaking the "pigs" from the "sow," etc. The labor of removing the iron from the cast-house also remained the same. With the advent of the basic open-hearth steel furnace, the demand for iron low in silicon and free from surface sand, brought about the introduction of iron chills or molds, by merchant furnaces proposing to make basic iron, that is, iron of a composition to suit the requirements of basic steel manufacture. Many of the casts run into these chills, upon being analyzed, were found not to meet the specifications of the buyer, being too high in silicon, or too high in sulphur. This iron became known as "misfit iron," necessitating its sale for some other purpose. The high sulphur pig was found suitable for puddling, a reduction in price being made to effect a sale, simply because it was "misfit iron." The puddle mills were thus made acquainted with sandless pig iron, and although introduced at some disadvantage, it is now used on the same terms as pig cast in sand. Some mills express a decided preference in favor of the clean iron, free from adhering sand. The misfit basic, high in silicon, found its way to foundries, to be remelted and run into castings. It might or might not have been of a composition to suit their requirements. Whether it was or not, it labored under the disadvantage of being a "misfit iron" and was naturally looked upon with suspicion.

Casting machines or tables are now replacing the chills in the Besemer furnaces of large capacity. These tables, when well constructed, are likely to give the relief so long sought for, obviating the necessity for a cast-house and do away with the exhausting and troublesome labor referred to. The furnace is tapped at such intervals as may be found convenient, and the molten iron run into ladles or cars of 20 tons capacity or larger.

Each car as filled is then emptied into molds of cast iron or of stamped steel plate, coated with a wash of lime, the mechanism of the table being so arranged that the molds move slowly in front of the ladle. It is evident that each lot of 20 tons, the ladle serving as a mixer, when poured into molds of the same section and cooled under the same conditions, must be practically uniform, one pig compared with the other. The steel trade, having arrived at an exact knowledge of the kind of pig iron required, is able to specify the analysis wanted. All purchases are made without reference to the accident of fracture. The limitations as to silicon and sulphur, to say nothing of phosphorus, are the determining factors. To the best of my information, sandless pig is preferred by Bessemer works to that cast in sand, while for basic steel manufacture, sand pig will not be accepted.

Foundries connected with steel works have been using sandless pig for a great variety of castings with entire satisfaction, the management simply specifying the analysis or the pig required. From time immemorial, the general foundry trade has been judging and determining the comparative values of iron for different purposes, by the fracture, without reference to the chemical composition. The experienced, observing man is able to make, at times, fairly correct guesses as to the quality of an iron, drawing his conclusions from the color of the fractured surface, the size of the crystallization, as well as the face of the pig. Demands on the foundry are now far more exacting than was the case years ago, and the margins of profit much smaller, calling for more exact methods, less guess work, and greater certainty as to the character of the castings.

It has been a matter of the greatest surprise and wonderment to me, upon visiting certain foundries, where the "rule of thumb" held perfect sway to the entire exclusion of any technical knowledge, that the mistakes and errors were not more serious practically and disastrous financially. If I were compelled, however, to make a choice between a practical man, thoroughly well acquainted with foundry work, a man of good judgment, but possessed of no chemical knowledge, and a theorist, equipped with

all that technical schools and a course of chemistry can give, but with little or no practical acquaintance with foundry conditions, I would certainly take my chances with the former. There is no reason, however, why the better qualities of both may not be combined in the one man. There is now so much literature on the subject of cast iron as applied to foundry work, that any fairly intelligent man can soon acquire all the chemical knowledge required to assist him in adjusting the mixture of iron, guided by the analyses furnished by an expert chemist, to suit the varying requirements of complicated or simple castings.

The most successful blast furnace managers are those who, by daily contact with furnace operations and close application, mastered the practical details and then supplemented this training by technical studies, to gain a knowledge of the value of the composition of ores, etc., as well as of the slag and iron product.

When I first became acquainted with blast furnace operations, they were conducted entirely on a system of guess work, so far as the material filled into the furnace was concerned. Analyses of slag or of the iron produced were seldom or never made. If anything went wrong, causing irregular work and reduced product of iron, with consequent increased cost, the blame was invariably placed upon the ore or coal. It was so much easier and satisfying to place the responsibility for one's own mistakes and errors upon the party supplying the raw material. As long as this system prevailed, there was no chance of any improvement. The modern blast furnace became a possibility only with more intelligent management, the management that without neglecting the teachings of practical experience, availed itself of all the help afforded by chemistry, to unfold a knowledge of the composition of the material used, the value of the various elements in their numerous combinations, as well as the composition of the iron produced. The data thus acquired by blast furnace managers as to the quality of various grades of pig iron, the influence of silicon and sulphur, etc., have been of more or less value to foundries.

We have thus been enabled to determine approximately the

composition of pig suited to varying foundry requirements, supplemented by the study of analyses of castings that were proved to be satisfactory. A blast furnace run in the old way could not now exist in competition with one managed under scientific methods.

Unless all signs fail, the same rules of growth and existence will hold good as applied to the foundry trade, and the "survival of the fittest" will, sooner or later, compel all foundries to avail themselves of the help afforded by scientific methods. Many foundries are under most excellent management.

There are many able men connected with foundry work, combining practical experience with technical attainments. These men know what they want and are thus able to specify as to the composition of the pig iron required, and their specifications, as a rule, are reasonable from the standpoint of the blast furnace manager, which cannot be said of all the specifications submitted by agents. To such men the accident of fracture is immaterial, so long as the elements named are within the limits specified. The percentages of silicon and sulphur determine, in great measure, the adaptability of an iron for general foundry work or for special work. They take advantage of the general trade custom of grading by fracture, the market price varying within the grade, to buy a No. 2 iron and at the same time specify a composition that can only apply to a No. 1 iron. As soon as foundries generally are sufficiently well informed as to the composition of the iron they requie, to specify the limits of silicon and sulphur, just so soon will the old system of grading by fracture disappear, and they will then be prepared to take advantage of the benefits afforded by the use of sandless pig iron or pig cast into iron molds.

It would be presumptuous for one having no practical acquaintance with foundry conditions, to advise or dictate to experienced men, but I am at a loss to conceive what benefit can be derived from converting into slag 20 or 30 pounds of sand for each ton of pig melted in the cupola. There is a bare possibility that the slag thus made, in connection with the ashes of the fuel, is of assistance in removing the sulphur of the fuel. If this

should prove to be the case, it would be a simple matter to add to the charge of clean pig, as much sand as may be required to make the necessary volume of slag. Much of the difficulty experienced in soft and gray foundry work, is due to the melting of the pig in the cupola, in contact with mineral fuel carying more or less sulphur.

The presence of manganese in the pig helps to remove the sulphur, but it is rather an expensive flux, paid for as it is at the price of iron. The same may be said of sand, if its only use on the pig is to increase the volume of slag. While it is true that a certain allowance is made for sand on the pig, it is doubtful whether the purchaser obtains 2,240 pounds of actual iron for each ton. The allowance made for sand is to cover the loss in handling, so that the purchaser may not receive less than 2,240 pounds of iron, plus the sand that adheres tightly. With the use of sandless pig the purchaser would always receive 2,240 pounds of iron.

There are many points of resemblance between blast furnace and cupola practice, enough to permit of arguing from one to the other. We have found that temperature, other things being equal, determines the percentage of sulphur in the pig. At high temperature of crucible or furnace, there is but little affinity between iron and sulphur; the slag takes up the sulphur, leaving the iron comparatively free. An unexpected stoppage, or a leaky tuyere, or any cause lowering the temperature of the crucible, will act to reverse these relations. The sulphur will attach itself to the iron. Sulphur in the pig increases the percentage of combined carbon and lowers the graphitic, thus affecting the crystallization, but not necessarily changing the percentage of silicon. Thus it is, that we occasionally get iron high in silicon, and, at the same time, high in sulphur, high in combined carbon, and low in total carbon. This iron might show a fairly good fracture in the sand pig, but if cast in an iron mold, the high sulphur would develop a chill in spite of the silicon, thus indicating very plainly that the iron was not suitable for light castings or castings that were required to be soft enough to machine easily.

In the cupola, however low the pig iron may be in sulphur, if not melted down hot, sulphur will be absorbed from the coal or coke, and the casting will be high in sulphur. Very few cokes will average less than 1 per cent of sulphur, while anthracite coal will carry from ½ per cent to 1 per cent. High sulphur in the casting will cause the iron to be hard, owing to formation of combined carbon, and coming into contact with the damp sand of mold, it will take a chill and excessive shrinkage will develop.

The knowledge that the iron mixture is all right would enable the manager to locate the cause of the trouble. While it might be easier to blame the pig and claim a reduction in price, yet this does not remove the real cause and the trouble is likely to reappear again and again, causing delays and loss.

While it is perfectly feasible to increase and multiply many times the percentage of sulphur in the pig, by remelting in the cupola at too low a temperature, no elevation of temperature will reduce the percentage of sulphur in the melted iron below the percentage contained in the pig or scrap charged, though good cupola practice may prevent any considerable increase, through absorption of sulphur from the fuel. The blast furnace and puddling furnace and possibly the basic steel furnace, can break up the combination of iron with sulphur and eliminate the sulphur, but the cupola cannot. Hence all scrap, as a rule, carries a larger percentage of sulphur than the higher grades of foundry pig iron. All grades and compositions of pig have their uses, and even sulphur is valuable to fulfil certain requirements. The whole difficulty consists in knowing just what is wanted in any particular case, and then adjusting mixture to suit.

In "blowing in" or starting a blast furnace, some years ago, the first couple of casts were usually worthless, a sort of nondescript iron, fitted neither for foundry nor mill use. It was made with a hot furnace above the tuyeres, but in the crucible, below the tuyeres, it underwent changes for the reason that the crucible was not hot enough to maintain the temperature of the slag and iron. This was corrected by increasing the blank charge of fuel to such an extent that there was no possibility of either slag or

iron reaching the crucible until its temperature was sufficiently high to prevent any change in either. Now, the first cast of iron will show about the same quality of product as any of the subsequent casts. I would argue from this experience that in cupola practice it not unfrequently happens that melted iron reaches the bottom of the cupola before the temperature is sufficiently high to prevent the iron from undergoing chemical changes.

When this iron is poured into molds, the castings are often worthless. The iron as charged at the top may be all right; as drawn at the tapping hole, it is all wrong. Blaming the pig and changing the mixture will not correct the fault. Positive knowledge as to the composition of the iron mixture and equally positive data as to the requirements of the castings to be made, would remove elements of uncertainty, and enable the manager to locate the trouble, so as to avoid a repetition.

We also find that atmospheric moisture plays an important part in the economy of blast furnace work. Roughly speaking, about five tons of air are required to make one ton of iron. Last June and July, 245 pounds of water in the shape of vapor was driven into the tuyeres for each ton of iron made, or over 125 tons of water in a week. The usual average for the year is about 160 pounds of water per ton of iron; but of course this varies with the location of the furnace, as well as the season of the year. The water is converted into oxygen and hydrogen gas at the expense of fuel in the crucible. Unless this is provided for, the temperature is lowered, sulphur in the iron increases, changing the relative proportions of graphitic and combined carbon, effecting the fracture and the market value.

Cupola practice is affected in the same way, but to a less degree, because in melting iron, much less air is used per ton than is required to make the iron. It is, however, an important factor and must be provided for to guard against bad heats. We have also learned that coke, if exposed, will absorb from 10 per cent to 20 per cent of its weight of water. If coke is charged by weight, one day we may get 600 pounds of coke per barrow and another day 500 pounds of coke and 100 pounds of water, which

is a poor substitute for carbon. On the other hand, different cokes vary in specific gravity, equal bulks varying 10 per cent to 15 per cent or more in weight. If the furnace is charged by volume, while the absorption of water is provided for, we are subject to violent fluctuations because of variation in actual weight of carbon, if cokes of different specific gravities are used.

All of these causes must be guarded against in blast furnace practice to insure uniform results and economical working, and the same causes apply more or less to cupola practice.

There are a hundred and one causes affecting the character and quality of castings produced by a foundry, other than the fracture, grade, or quality of pig iron used. Such being the case, it becomes all the more important to eliminate, by the application of scientific and technical helps, such of the disturbing causes as are within control. There has been so much written of late upon the chemistry of cast iron as applied to foundry practice, the influence of the several alloys, silicon, sulphur, carbon, phosphorus, etc., that it is not worth while for me to discuss the subject, however attractive it may be.

My object has been to call attention to causes of trouble that are not often referred to. Other causes will suggest themselves to every experienced foundryman, that pertain solely to the foundry, especially to the fine art of molding, designs of patterns, treatment of sand, pouring of iron, condition of cupola, volume of air, etc.

The furnace manager has his own troubles also. To one well acquainted with the cast-house work of a blast furnace, the molding of the pig beds, the running or casting of the iron, and the physical causes by which the fracture of the iron is influenced, it has been a wonder that, notwithstanding the advance in technical information, so much stress should still be placed, by our foundry friends, upon the accident of fracture, as governing the quality of the iron, to be used for any particular purpose. I do not question that the fracture is a guide to a certain extent, and the fact that it has been so long employed, in the absence of any better method, is proof of its old-time usefulness.

There is room for so many mistakes and errors, however, that have been developed only by the accumulation of hundreds and thousands of analyses, that it would seem that this custom should no longer stand in the way of improvements, that ultimately would prove of more or less benefit to the foundries. There are many causes affecting the fracture, independent of the composition. The fracture may be a reasonably safe guide to the blast furnace manager, especially if he has made a study of many analyses, comparing them with the physical appearance of the iron, and knowing the conditions under which the iron was made and cast. I do not know of any better pyrometer to determine the relative temperatures of the blast furnace, than the silicon and sulphur contents of the iron. The time of cooling, or rather of passing from liquid to solid state, and the silicon contents are exchangeable terms, the total carbon being constant.

Large masses cool slowly; graphite carbon separates, even if silicon is very low. If the section of a casting is $\frac{1}{8}$-inch or less, causing the hot metal to cool quickly, silicon must be high to compel or force carbon to assume graphitic form, in spite of the rapid cooling. When a furnace containing 40 or 50 tons of iron is tapped, under a blast pressuer of 8 to 10 pounds per square inch, the flow of metal down the main runner, supplying the rows of pig beds, may become unmanageable. The more rapidly the iron is run, other things being equal, the more open will be the fracture and the larger the proportion of No. 1X. We therefore aim to run foundry iron as fast as the men can handle it. Some beds may be sheeted or filled to overflowing, while others may only be partly filled. The large pigs will go into the No. 1X pile, while the smaller ones, from adjoining bed, may be piled as No. 2. Some of the beds may not be level; they may hang too much in one direction. One-half of the pigs may be filled to overflowing, and the balance only partially. The bed is cut off. The iron seeks its own level, passing from one set of pigs to another. The flow of the iron disturbs the crystallization, so that the pigs first filled, and from which the iron flowed to fill

up the others, will show a No. 2 or even a No. 3 fracture, while the balance of the bed, and the beds adjoining above and below, may be No. 1. The face of the pigs thus drained will show a concave surface, because of the metal being drawn from the interior, while the pigs receiving this iron will have a convex face. The foundryman condemns the one because its appearance indicates high shrinkage, while the latter is entirely acceptable.

The first three or four pigs in each bed, the pigs that fill first, will almost invariably be No. 2 or even No. 3 in fracture, while the balance of the bed may be No. 1, for the reason that the iron is not at rest, the movement of the metal, some molds filling up and then emptying partially, interferes with the law governing the formation of large crystals. Sometimes an obstruction in the tapping hole causes the flow of iron to almost cease for a few minutes. If a bed happens to be only half full, the fracture will show No. 2, while the preceding bed, run more rapidly, and completely filled, will be No. 1. Slow running is destructive to open crystallization, while rapid running and slow cooling is favorable to open iron, and a large percentage of No. 1.

Now when we find that all of this iron is parctically of the same composition, made under the same furnace conditions, and that the differences in fracture are due solely to physical causes, the fallacy of grading one pig No. 1, and another pig, only a couple of feet distant, in the same bed, No. 2 or even No. 3, becomes evident. Any inference that all the iron graded and sold as No. 2 and No. 3 foundry is sorted from No. 1 casts, and has the same composition as the No. 1, would be far from the truth. While it is true that a certain percentage of the lower grades show the same analysis as No. 1, yet by far the greater tonnage is made under different funrace conditions, and will show different analyses. It sometimes happens that a foundry receives No. 3 grade, selected from a No. 1 cast, and finding that it answers the purpose just as well as No. 1, the buyer jumps to the conclusion that he will save considerable by using the No. 3, and places his order for a large amount. The next car received, while of ap-

proximately the same fracture, may have been made under different furnace conditions and be of entirely a different composition. Trouble follows and misunderstandings arise. Our pig beds are necessarily kept very wet, otherwise the cores will not stand. The molten iron is run 50 or 60 feet, in the main runner, and subdivided into smaller streams into equally wet beds.

It has been noticed that the same iron run into chill molds shows higher percentage of graphitic carbon than when run into the sand beds. This probably can be accounted for from the fact that the iron molds are dry and frequently warm. The following analyses, made by H. V. Wille, chemist, Burnham, Williams & Co., Dec. 30, 1895, of Warwick, cast No. 81, of drillings from sand pig and drillings from pig cast in iron molds will illustrate:

	Cast No. 81 Chill Molds.	Cast No. 81. Sand Pig.
Graph. C	2.87	2.57
Comb. C	0.48	0.42
Total C	3.35	2.99
Manganese	0.42	0.41
Phosphorus	0.36	0.36
Sulphur	0.017	0.010
Silicon	1.50	1.52

However regular any furnace may be working, and however uniform in appearance any cast may be, there is an unavoidable variation in the composition of one bed of iron of any one cast, compared with every other bed, and a variation between pigs of the same bed.

For some years past we have been sampling every cast liquid. The iron is taken from the main runner and poured into iron cups. The bottom of the cup is 1 inch thick and the depth of liquid metal in cup is about 1 inch. These samples. as soon as they can be removed from cups, are quenched in water and

drilled. The borings are mixed thoroughly, and analyzed. Frequently several analyses may be made for one cast, if any considerable difference is noted in different parts of the cast.

In order to secure practical uniformity, the different beds of a cast are broken over a block, the different pieces are then sorted and piled by fracture, and by the time they are again handled in loading a car, there is such an intimate intermixture, that the car as loaded is fairly represented by the cast analyses. We invariably get two grades by fracture, from each cast, sometimes three, so that we will have two or three piles of iron, No. 1, No. 2 and No. 3 foundry by fracture, all of the same analysis. Even in the same pig, the appearance of the fracture depends upon whether the pig is broken in the middle, close to the sow, or close to the end or point. The crystals are largest nearest the sow, the end that cools the slowest, while near the point they will frequently be small and lighter in color, because of more rapid cooling. To strike a fair average, we aim to break each pig in the middle. If the pieces are re-broken at the foundry, there will be found a considerable variation. The half next to the sow when re-broken may be open, while the other half may be close. The crystals in the sow are more open than those of the pigs in the same bed, as the section is larger and the cooling proceeds slower. Hence it is that some furnaces make pigs of large section to please the eye of the consumer.

Uniformity can only be secured by unceasing watchfulness, and the exercise of the greatest care, together with the help afforded by analysis. We have paid especial attention to uniformity of shipments, and while any one or two pigs may not show the same analysis, differing from one another, and differing possibly from the average of the cast, yet the cast analysis will fairly represent the iron as used in quantity. Uniformity can only be secured by selection, guided by analysis, and by intimate intermixture. Appearances are very deceptive, even to the furnace manager, with all the helps afforded by knowledge of furnace conditions. Every cast may vary more or less from every other cast of foundry iron. The use of iron by brands or names or

grades does not furnish any guarantee of uniformity, unless there is selection and care exercised at the furnace. We are more or less dependent upon ignorant and inefficient help, subject to errors of judgment and of ignorance and carelessness, so far as grading by fracture is concerned.

We have recently been considering the adoption of of a casting table. A favorable decision is necessarily dependent upon the favor with which such a departure from old methods will be received by our foundry customers. The mill consumers will offer no objection, but there is more or less doubt in regard to the foundry trade, especially the smaller class of foundries. I question whether there would be any pecuniary advantage to the furnace company, as the investment for one furnace would be so large as to counterbalance any possible saving in cost of handling our product in this way, as compared with sand pig. Our advantage would consist in doing away with the most arduous work around the furnace, and at the same time enable us to insure greater uniformity in our shipments, and be less dependent upon ignorant and unskilled labor. In explanation of this statement, the following method of procedure will probably be convincing:

Upon tapping the furnace, the molten iron will be run into 20-ton ladle cars, a cast of 40 tons will require two cars. When the first car is filled, the iron will be poured into molds made of cast iron or plate steel, coated with loam or lime, to protect them and insure no sticking. It is evident that the iron of the first ladle will be so intimately mixed by the filling and pouring, that each mold will contain iron practically of the same composition, which will be cooled under practically the same condition; hence the lot of 20 tons, pig for pig, will be more nearly uniform than is possible under the present method of running an equal tonnage into ten different beds. Each ladle will be sampled and analyzed, so that the composition of each car load of 20 tons will be definitely known.

The effect of the iron mold upon the fracture of the pig will probably be to tighten or close the grain somewhat, so that the

present custom of grading by fracture would have to be modified to meet the changed conditions, or a system of grading developed depending upon the composition. For instance, an iron of 2.50 per cent to 3.00 per cent silicon and 0.02 per cent or less sulphur would be No. 1.

Silicon 2.00 to 2.50
Sulphur 0.02 and under .....No. 2X.

Silicon 2.50 to 3.00
Sulphur 0.05 or less .....No. 2 soft

Silicon 2.00 to 2.50
Sulphur 0.05 or less .....No. 2 plain.

Silicon 1.50 to 2.00
Sulphur 0.05 or less .....N. 2 strong.

Silicon 1.50 to 2.50
Sulphur over 0.05 .....No. 3 foundry.

In the absence of any grade number, specifications would call for the silicon and sulphur to suit the particular requirements of the purchaser.

If the pig iron was used directly in the form in which it comes from the furnace, that is, if the pig itself was planed and drilled, etc., the objection that the chilling action of the iron mold would harden the surface of the pig, might be valid enough, but as the pig is re-melted, this objection would seem to lose its force. Other things being the same, the temperature of the blast furnace determines the composition of the iron, and the composition of the iron after being re-melted in the cupola, determines as a rule, occasionally apparent exceptions occur, the quality and fitness for any particular class of castings. Whatever may be the method of casting at the blast furnace, whether the iron is run into wet sand, dry iron molds, or granulated by running into water. In the latter case all of the carbon would be combined, and the particles, or pebbles of iron, would be white.

If the iron thus changed to white by rapid cooling, had been made in a hot furnace and contained 3 per cent silicon and not over 0.02 or 0.03 per cent sulphur, upon re-melting in the cupola,

it would make a soft gray stove plate or the lightest hardware casting, without any evidence of chill. This has been practically demonstrated.

Our experience with our sample chill cups, extending over many years, and representing thousands of casts and analyses, would prove that iron cast in metal molds instead of sand, will indicate to the purchaser, after a little experience, more accurately the quality of the iron for foundry uses than it is possible to gather from the fracture of any sand pig. We can guess approximately the composition of any cast by the appearance of the fractured chill cup samples, while we would go very far astray frequently if we relied upon the fracture of the pigs of the same cast, as the fractures vary so greatly, depending upon the sizes of the pigs, the manner in which the iron was run, etc. By comparing the chill cup samples, day after day, with the analyses, we find that the chill cup not only acts as a guide so far as the silicon is concerned, but is an infallable detective of sulphur.

Our pig iron, low in manganese, with 1.5 per cent silicon and sulphur down to 0.03 per cent, will not take a chill in this cup. If the silicon falls to 1 per cent, with the sulphur 0.02 per cent, there may be a slight chill; but let the sulphur increase to 0.08 per cent, a chill ½-inch in depth will show. Pig with 2 per cent to 3 per cent silicon, and sulphur up to 0.05 per cent, will not chill in the cup, but if the sulphur increases to 0.10 per cent, even 3 per cent of silicon iron will show a chill. The chill caused by sulphur is entirely different in appearance from that produced by low silicon and is easily distinguished. With pig of 0.50 per cent silicon and low sulphur, the test piece 1 inch thick will show ½-inch chill. If the sulphur is high, say about 0.10 per cent, the test piece will be solid white. The most beautiful iron of No. 1 fracture is the low silicon and low sulphur variety, with high carbon. Such an iron, re-melted in a cupola and run into thin castings, would be white and brittle. Run into heavy castings, like ingot molds, it will be soft and strong, outlasting many times the ingot molds made of 2 to 3 per cent silicon pig.

Our experience with the chill cup test pieces, showing the in-

fluence of sulphur, has enabled us to render more or less assistance in accounting for many of the troubles our foundry friends encounter. It is not common for the higher grades of the best makes of foundry iron to contain sufficient sulphur to be injurious; but in re-melting, if the cupola is not hot enough, or if the bottom is too cold to receive the iron, the absorption of sulphur from the fuel is frequently ruinous. Hot, high silicon iron, coming into a comparatively cold bottom, or tapped into cold and damp ladles, will undergo chemical changes, causing a white core, surrounded by a gray skin, that frequently causes the loss of many light castings.

Foundries, therefore, that operate on too small a scale to warrant the employment of a chemist, or large foundries, depending upon the analyses furnished by the furnace company supplying them with iron, can soon learn to judge sandless pig and determine the quality by inspection much more accurately than is possible with sand pig, however experienced and skillful the inspector. In purchasing a carload of sandless pig the buyer is sure to get as many pounds of iron as he pays for. It will not be necessary to melt tons of sand in a year, except as it may be found necessary to use it as a flux, and then it can be added in the shape and in the quantity that may be most convenient and economical.

The secret of success, in foundry as well as in blast furnace practice, is to know enough to know how little one knows and how much there is to be known, close application and hard work. I quote as follows from a recent letter of Mr. Thomas D. West: "You may not be aware of it, but the fact is that if one-half of one cast is run into sand mold and the other half into chill molds, the latter would give the softer iron when re-melted. Chilling of pig metal can only effect the state of the carbon. The silicon, sulphur, manganese, and phosphorus remains the same in both cases, so that as long as you have 2.50 to 3.00 per cent silicon, and not over 0.02 per cent sulphur in the cast, it matters not if the pig showed a chill, the iron would make a softer casting than had it been cast in sand molds."

As a matter of fact, it is extremely doubtful whether a pig iron with 2.50 to 3.00 per cent silicon and 0.02 per cent sulphur could be made to show a chill by casting in any iron mold. It would have to be run in water in order to cause sufficient carbon to assume the combined form and thus cause the iron to become white. When the blast furnace is making a high grade of foundry iron, the atmosphere of the casting-house, when the iron is being run, is filled with kish or graphite, thrown off by the molten iron. The trough and sand runners frequently show graphite in abundance. When the molten iron is at rest in the beds, graphite can be noticed floating on the surface of the pigs. As the iron cools slowly, the graphite seems to accumulate on the surfaces, the quantity increasing the slower the iron passes from the liquid to solid condition. When the same iron is cooled quickly, as frequently happens when a bed is partially sheeted, and a thin layer spreads over the cores separating the pigs, this does not separate graphite. The quicker cooling seems to confine the carbon and keep it in the iron. Of course the graphitic carbon that exudes is washed off when the pigs are sprinkled with water, and is lost.

The exudation of carbonaceous powder on the pigs is the more evident the lower the silicon contents, that is, with the iron carrying 1.25 to 1.75 per cent silicon, the amount of carbon thus separated is greater than when the iron carries 2.00, 2.50 or 3.00 per cent silicon. The face of this pig has a peculiar etched appearance, indicative of strong pig. A hot furnace, and consequently low sulphur, is a necessary condition. This fact may explain the assertion of Mr. West. Iron run into chills sets more rapidly than when cast in sand, which may thus act to retain the carbon.

The analysis of Mr. Wille, chemist of Burnham, Williams & Co., of cast No. 81, shows 3.35 per cent carbon in the pig cast in chill molds, as compared with 2.99 per cent in the sand pig. The same chemist made determinations of other casts of Warwick iron as follows:

CAST No. 83—WARWICK IRON

	Sand pig.	Iron in chill molds.
Comb. carbon	0.42	0.68
Graph. carbon	2.48	3.03
Total carbon	2.90	3.71
Manganese	0.40	0.51
Phosphorus	0.42	0.41
Sulphur	0.012	0.056
Silicon	1.52	1.24

CAST No. 91—WARICK IRON.

Comb. carbon	0.49	0.54
Graph. carbon	2.03	3.01
Total carbon	2.52	3.55
Manganese	0.52	0.51
Phosphorus	0.38	0.44
Sulphur	0.010	0.010
Silicon	1.38	1.28

We have not run any iron into chill molds since the early part of 1896, and have no further data on this subject. Our carbon determinations are made from samples obtained by drilling the pigs, all other elements being obtained by drilling of chill cup samples.

Since my attention has been called to this side of the question, we have had time to make only a few determinations of carbon from chill cup samples, compared with pigs of the same cast, as follows:

	Sand Pig.		Chill Cup Samples.	
	Cast 124.	Cast 132.	Cast 124.	Cast 132.
Graphitic carbon	3.40	3.59	3.58	3.64
Combined carbon	0.46	0.07	0.50	0.25
Total carbon	3.86	3.66	4.08	3.89

A distinction is to be made between iron run into chill molds, arranged in series corresponding to the beds of sand, and iron cast in molds arranged on a casting table, the molds being filled by pouring from ladle car. The uniformity pertaining to the latter method, pig for pig, will not apply to former, which are filled under the same conditions that apply to sand beds.

PROCEEDINGS OF THE PITTSBURG FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Pittsburg Foundrymen's Association was held Monday evening, May 22, with President Wm. Yagle in the chair. After the approval of the minutes of the previous meeting as read by Secretary F. H. Zimmers, the names of the following persons and companies were presented as having been approved by the executive committee and were declared elected to active and associate membership respectively:

Active Membership.—William Moen, DeHaven & Co., Allegheny; Alonzo Kim, Foreman Mesta Machine Co., South Side, Pittsburg; Wheeling Mold & Foundry Co., Wheeling, W. Va.; Samuel Weekes, Lorain Steel Co., Johnstown, Pa.; C. S. Birmingham, Pittsburg Lamp & Brass Co., Allegheny; Dave Carlin, Carlin Mnfg. Co., Allegheny; Kinzer & Jones Mnfg. Co., Pittsburg; John C. Meyer, Foreman Thos. Marshall, Pittsburg.

Associate Membership.—A. H. Neal, Pittsburg; Reed F. Blair & Co., Pittsburg; L. K. Brown, Zanesville, O.; A. M. Ayers, Zanesville, O.; Robert B. Lean, Allegheny.

The following paper was then read by M. A. Moran, foreman of the foundry of the Keystone Bridge Works:

THE USE OF SANDLESS PIG IRON IN THE FOUNDRY.

Doubtless one of the most important subjects before the foundrymen of the world to-day, is being earnestly discussed, and put to practical tests wherever possible, aiming to arrive at a conclusion, which will show the merits, or demerits of sandless pig iron in the foundry, as against the use of sand cast iron. Of course, foundrymen, who all their lives have judged pig iron by its appearance, do not look kindly upon a departure which at one sweep destroys the knowledge gained in a lifetime. Nevertheless, in these days of progress, many practical problems have been worked out successfully by the application of scientific methods to actual demonstrations, which show decided improvement over the old methods. And those who still cling to the old and out-of-date ideas, will sooner or later be compelled to withdraw from

the race, through not having taken advantage of the experience acquired by their more progressive competitors.

Much has been said about sandless iron for the foundry, and in nearly every case it has been admitted that sooner or later the use of sand-cast pig iron will be a thing of the past, many agreeing that the proper way of making up a mixture should be by analysis only. It is an established fact, as many of you know, that there are great advantages in making steel from sandless iron. Likewise founders who have adopted sandless pig iron fully appreciate and admit that there is an advantage by its use; and were I able by this address to give you the experience I have had, I am quite sure those who are still skeptical would be convinced that sandless iron for the foundry with a mixture based upon analysis is the proper thing, and that by its use superior results are obtainable.

Doubtless many of you were of the same opinion that I was, before I went through the experimental stages—that iron cast in iron molds would be unfit for foundry use, believing that when so cast there would be a chill in the pig, which the foundrymen thought would follow into the castings made from it. I have learned, however, to my entire satisfaction, that this is not the case. This can be seen by examining some of the samples I have brought with me, if you will take the trouble, and thus be relieved of any doubt. Several years ago we began to use pig iron cast in stationary chills with good results, but with the sandless pigs from the Uehling casting machine we get still better results. The iron is cleaner and more uniform. This is no doubt due to the fact that instead of running direct from the furnace into pig beds, it is collected in large ladles in which it is not only thoroughly mixed, but the impurities have time to rise to the top, carrying with them much of the sulphur and all the slag, etc. The iron furthermore is absolutely free from sand and scurf, and for that reason comes much cleaner from the cupola. We have used nothing but sandless pig iron in our foundry for the past two years.

We make all kinds of machinery castings, some of which are quite thin, and require very fluid iron. The pig metal we use

averages 1.00 to 1.50 in silicon, graphite carbon 2.85, combined carbon .45, sulphur not to exceed .03. My foundry record, for the period during which we used nothing but sandless iron show fewer bad castings and considerable economy in fuel and time. We get hot metal by using one pound of coke to 10½ pounds of metal. When we were using sand iron the ratio was 1 to 7. In fluxing we now use 100 pounds of limestone for 20 tons of metal, while when using sand iron it required 150 pounds of limestone for 20 tons of metal. Our cupola does not choke or slag, and we run the 20-ton heat without waiting for metal. The average loss between the iron weighed into the cupola and that of the castings was 6.43 per cent. in 1898, and the average amount of bad castings was 1.65 per cent. The shrinkage is considerably less than what it was when running on sand iron, we now make our patterns allowing 1-16-inch to the foot for shrinkage. This I believe is less shrinkage than is generally expected in the average foundry. Our experience with sandless pig iron in the foundry is so satisfactory that we shall not voluntarily return to the use of sand iron. There is a large economy in fuel, economy in flux, more prompt and satisfactory melting, a saving in time, reduced wear and tear, and a less per cent. of defective castings.

DISCUSSION.

Dr. Moldenke said he could not see why the use of sandless pig iron should reduce the shrinkage of castings. He asked if the same amount of coke was used as before, with the sand cast pig.

Mr. Moran: We do not need to use so much. The heat does not have to go through sand and dirt, and the coke seems to take better hold of the iron.

Dr. Moldenke gave it as his experience with the harder irons that there would be a great difference in the grain of the castings between a mixture of half pig and half scrap, and a mixture of one-fourth pig and three-fourths scrap, and Mr. Moran explained that in making racks for bridges they had to use all pig, and the rule of 1-16-inch to the foot for shrinkage came out all right. These racks had to be very exact.

Mr. Kebler said that the small shrinkage was in all probability due to the low sulphur and phosphorous in the sandless pig being used. He understood this pig had formerly been used only for the basic open-hearth process, and for that reason they had been using an extra amount of limestone in the blast furnace, which gave low sulphur and rather low silicon, while this kind of iron would naturally have a small shrinkage. Supplementary to this, Dr. Moldenke claimed that even with the same chemical analysis, different physical treatment makes a difference in results, as to shrinkage for example.

In answer to a question Mr. Moran said there was no difference in the scrap carrying power made by using sandless pig. In his own foundry they carry their own scrap, sprues, worn-out hammer dies, old machinery, etc. They melted from 18 to 20 tons a day, and followed the rule of 1-16-inch shrinkage all the way through.

A member here stated that in some cases, with sand cast pig iron, no shrinkage at all is allowed, and in other cases the rule is only 1-16 inch.

Mr. Sleeth asked if at the Keystone Bridge Works foundry they had ever cast between yokes, so as to get an exact result, pointing out that in some cases castings came out larger than the pattern, with any kind of iron, because through ramming out the mold would be larger than the pattern. It developed that the experiment of casting between yokes, to determine exactly the shrinkage, had never been tried, and in answer to questions Mr. Moran further stated that they had made housings weighing six or seven tons with this iron. They had not noticed so much scum on the iron in the ladles as before the adoption of the sandless pig. It was here stated that members had noticed quite a scum on the ladles with pig cast in the old stationary chills, which had been tried at a number of furnaces. In puddling with chilled iron it was remarked that the iron would be brought to "nature" from 15 to 20 minutes sooner than with sand cast iron.

"Modern Foundry Buildings" was the topic chosen by Armin Schotte for the second paper of the evening.

MODERN FOUNDRY BUILDINGS.

Money saved is money earned, and this old saw is being continually exemplified in new ways. In a foundry an account can be kept of every pound of material entering the cupola and every pound of salable material which comes out of it. All other items which affect the cost of the finished product can be readily recorded and comparisons and experiments made to either increase the quality and quantity or reduce the cost. Supposing the foundry to be a most modern one, having a machine shop connected with it, the performance of different tools for doing the same class of work may be judged in the same way, although a much longer time is usually required to do this. A foundryman soon becomes very expert, and with the means at hand turns out the maximum product at a minimum of cost for his particular establishment.

Raw materials can be easily changed and tools rearranged to suit the occasion, but the defects in a building once up can not be remedied without serious interference with the work, and added expense. How many foundrymen have ever considered that their building, besides being merely a covering to keep off the weather, is, to a certain extent, also a tool, and requires the special knowledge of a skilled engineer for its economic design. The foundryman creates the conditions he wants fulfilled, and the specialist fulfills them.

It is at once apparent that since the advent of overhead traveling cranes the whole structure has become a part of this tool, the columns being necessary for its support, and the trusses being braces for the columns. The conditions to be met here now are naturally very much more complex than formerly, and the results which might happen if the design of a structure carrying several cranes of 30, 60 or even 100 tons capacity, were left to inexperienced hands are too awful to contemplate.

Look at many of the former buildings put up at different times during the last twenty-five years, and you wonder how it is possible for a molder to work to the best advantage and get good castings. It is very evident that the subject of light

has in these cases not been properly treated; for even if a certain number of windows and skylights have been provided, they have mostly been poorly distributed, the areas lit up by each very often overlapping to a considerable extent, or they been so placed that to clean them conveniently is sometimes next to impossible. A great help in having clean windows is to keep them as much as possible from becoming dirty. In a foundry, with its gases and dust, good ventilation does this.

It is very apparent that the labor cost in a dark building will exceed that in a well-lighted one, for men can work faster in the latter. By saving time on each operation the foundryman is enabled to use the floor space oftener, and the output is thus increased. The matter of the building, its size, arrangement, and structural features are therefore very important.

Although the effect on the cost of finished product, of a building in whose design the features mentioned above have been well taken care of, can only be approximated, estimate can be made on the first cost of construction, which determines such fixed charges as interest on the capital invested, insurance, cost of repairs, and charges toward sinking fund.

When the variety of building material was limited to a few articles, the choice was easy, but at the present time the number of articles offered in the building line are almost bewildering, and it requires an expert to separate the wheat from the chaff. In such large foundry buildings as those of the Westinghouse Air Brake Co., McConway & Torley Co., and the new works of the Mesta Machine Co., at West Homestead, the quantity and cost of each separate item is considerable, running up to many thousands of dollars in each case, the total footing up to a good-sized fortune. It is obvious that the selection and disposition of these things should not be left to interested parties, whose judgment is affected by the possible benefits their bank account may derive for the time being. That construction is the most economical which, with a minimum cost of material, is the most lasting. Iron and steel have taken the place of wood wherever possible. The conditions which have brought about this change are

too well known to need recounting here. The iron-clad building of to-day is a construction which commends itself principally on account of its low first cost, fire-proof qualities, and ease of erection. It also requires no separate foundations for the side walls. The material used is corrugated iron or steel, either black or galvanized. If black, a protective coating of paint is absolutely necessary, and it is usually put even on galvanized iron.

The objections which can be urged against this construction are the short life of the covering, despite the constant and costly attention to preserve and keep it in repair, and the poor protection it affords against changes of temperature. This changing temperature is its worst enemy, for the moisture which condensed on the surface as the atmosphere cools off will reach the metal through the innumerable small cracks caused in its protective covering by constant expansion and contraction. If this moisture is charged with acid gases, as is the case in a foundry, the final result is hastened. Corrugated iron or steel is not the most economical covering for a foundry building.

For side walls and partitions a most excellent material is brick, and as the now usual steel skeleton construction does not require them to act as supports for the floors or the roof, they may be made as thin as will insure their stability against the effects of constant vibrations due to the passing of railroad trains, for few foundries are very far from the main line, and the machinery of the plant. It is poor economy to use anything but the best cement mortar for joints. For the roof covering only a good quality of slate should be used. This should be used on good, stiff wood sheathing, preferably flooring which is covered with a layer of first-class roofing felt, or it may be wired to steel slating angles put about 10 inches apart. This latter construction is more costly than the other, but there is no danger of fire.

It is a curious fact that in different parts of the country different styles of factory buildings prevail for one and the same kind of manufacturing. This is due in a certain degree to the conservatism, not to say ignorance, in many cases, of owners who have accepted as good a certain pattern of their neighbor, and

who do not trust their judgment with regard to offered improvements. Pittsburg is happily a rare exception to this practice, for the success of Pittsburg's manufacturers is due to their progressiveness and willingness to try anything which has a reasonable chance of being a success.

The writer has been enabled recently to put up what fulfills to the greatest degree all conditions required of a good construction. It is called a "cementine" construction, because, although the framework of the building consists of steel, as usual, the covering is made of steel embedded in concrete. The material used in the concrete is a boiler cinder, sand and cement. It is possible in this manner to construct walls with a thickness of two inches, which combines all the best points of an ordinary brick wall, and a roof not exceeding three inches.

This system admits of the omission of the usual wall foundations, and a wall 40 feet high is no thicker and no more expensive per square foot than a wall 10 feet high. The construction is absolutely fire-proof, does not sweat, and is warmer than a brick wall because less porous and a poorer conductor of heat. The construction is not new in principle, but has stood the test of time, only the manner of its application being novel. It is to the writer's mind the ideal construction for foundry buildings, for it combines low first cost with strength, the cost not exceeding that of any other first-class construction, while it is absolutely fire-proof, the repairs are nominal, it will outlast any other construction, and it makes a pleasing appearance.

DISCUSSION.

Mr. Schotte stated that he had read the paper merely as an outline, or preparation for a discussion relative to the construction referred to. He exhibited photographs showing the Walker soap factory, and other buildings, erected of this construction. The principle is that of making a framework composed of either expanded metal lath, or wire lath, on which the cementine is built up, the thickness being, say, two inches. For floors, heavy expanded metal is used; for roofs, it is used lighter, while for sides it is lighter still, and of finer mesh. The wire lath which is used

sometimes is stiffened in one of two ways: By round rods woven into it, spaced 16 inches apart, or closer, or by heavy gauge sheet steel strips, bent into a V-shape, and spaced in the same manner. The first cost is not cheap, although the cost of material is not much, but the labor involved in erection is considerable. But the construction is considered cheap in the long run because it is practically everlasting. It will stand intense heat, and when hot may have water sprayed on it. Pieces have even been made so hot that the steel inside fused, and these pieces have been thrown in water, without being cracked. On account of its being a very poor conductor of heat it will not sweat. A case was mentioned of a large building, just being completed, in which there was a 4-inch and 2½-inch steam pipe, used for power in some erecting work. There was a heavy fall of snow, and the heat of the roof, derived from these steam pipes, was sufficient to melt all the snow, so that there was no snow left on the roof except at the eaves, although the fall amounted to 8 or 10 inches.

Mr. Seaman asked if this material had ever been used for a machine shop floor or where other heavy work was done, and it was answered that it had been used as a floor in a brewery, where heavy barrels were being rolled about, and that one of the barns of the Consolidated Traction Co. had a floor of this material, on which a car had been run. It is stiff, yet elastic. With a good-sized span, a marked deflection can be noticed with a heavy load, yet it returns back to its place when the load is removed. In erection it is necessary that the arrangement be such that the steel is placed in tension and the cement in compression, because the cement has very little tensile strength. The result is, that when something has to give, it is the steel which yields because its tensile resistance is less than the compressive resistance of the cementine. In roofs the panels are usually of 10 feet span, the cementine being 3 inches or 2½ inches thick, and it may be struck with a sledge without damaging it. The proportions in making the cementine are one part of cement to 1, 2, 6 or 7 parts of clinkers, according to the size and condition of the latter. Mr. Seaman recalled a road which he had built of blast-furnace slag,

using heavy pieces first and covering these with finer. In three or four years it was necessary to take this up, and it was necessary to use powder, as the whole had become thoroughly cemented together.

President Yagle congratulated the Pittsburg Foundrymen's Association on having entertained the best and largest meeting yet of the American Foundrymen's Association, and he said he learned from visitors that all were highly pleased with the convention. Mr. Seaman spoke of the work which should be done by this association in organizing kindred ones, so that there would be a still better attendance at the next national convention, wherever it will be held. On motion of Mr. Seaman, the secretary was instructed to write letters of thanks to the various persons and concerns contributing in different ways to the success of the convention; to those who had loaned the interesting exhibits, to the typewriter people, the telephone company, and the donors of the many things which had helped to make the time enjoyable, including the Westinghouse Air Brake Co., which furnished the special train on Wednesday afternoon.

PROCEEDINGS OF THE WESTERN FOUNDRYMEN'S ASSOCIATION.

The annual meeting of the Western Foundrymen's Association was held at the Great Northern Hotel, Chicago, May 10th, at 7:30 p. m., Vice-President A. M. Thompson in the chair.

The minutes of the previous meeting were ordered approved as published.

The secretary presented a verbal annual report, calling attention to the fact that the association has not been as prosperous as could be wished in the past year, and stating that the membership has fallen off to a considerable extent. The secretary urged every member to use his influence to secure new members and to arouse new interest in the work of the association. It had been suggested that the association take up the question of sustaining prices in the territory it covers, and the secretary reported that a committee had been appointed to canvass this question, with instructions to make a report embodying some plan whereby the idea could be adopted. The work of the association in the past year has not covered much ground, as it has been almost impossible to secure papers to be read at the meetings. The report of the secretary was received and filed.

The treasurer reported as follows:

TEASURER'S REPORT, MAY 15, 1899.

Balance on hand May 15, 1898	$213.47
Indebtedness, May 15, 1898	Nil
Total receipts, May 15, 1898, to May 15, 1899	383.58
Expenditures, May 15, 1898, to May 15, 1899	588.85
Balance on hand, May 15, 1899	8.20
Indebtedness, May 15, 1899	Nil

Details of Expenditures.

Previous secretary's expense	$ 7.00
Printing and stationery	114.25
Postage	75.10

Stenographer	356.00
Exchange	.45
Banquets, entertainments, etc	30.00
Miscellaneous expenses, telegrams, express, etc	6.05
Total	$588.85

Comparison of Years Ending May 15, 1898, and May 15, 1899

	May 15, 1899.	May 15, 1898.	Decrease.
Total Receipts	$383.58	$ 944.17	$560.59
Total Expenditures	588.85	1,199.38	610.53
Balance on hand	8.20	213.47	205.27

The treasurer's report was received and ordered placed on file.

The committee on the control of prices and uniform credit system, appointed at the last meeting, reported little progress, and asked for more time, which was granted.

The election of officers was then proceeded with, resulting as follows:

President, C. J. Wolff, L. M. Wolff Mfg. Co.; vice-president, William Ferguson, Wm. Ferguson Foundry Co.; secretary, B. M. Gardner, The Iron Trade Review; treasurer, R. J. Cleveland, Cleveland & Barr; directors, James Frake, A. M. Thompson, Link Belt Machinery Co.; C. H. Hopke, Western Foundry Co.; M. Salomon, Chicago Architectural Iron Co.; F. G. Coffeen, Deering Harvester Co.; editing committee, B. M. Gardner, J. E. Evans, of S. Obermayer Co., and W. A. Jones.

The chair was authorized to appoint a committee of three to secure the next convention of the American Foundrymen's Association for Chicago, and the committee was instructed to use its best efforts to this end. C. J. Wolff, S. T. Johnston and W. A. Jones were appointed as such committee.

A general discussion of the benefits to be derived from membership in foundrymen's associations followed. The meeting was addressed by Secretary John A. Penton, of the American Foundrymen's Association. Mr. Penton gave some reasons why the various foundrymen's associations have not been as success-

ful as usual in the past year, and expressed the hope that with the better business the foundrymen of the country are now getting the membership and attendance at meetings of all the associations will be largely incerased. Mr. Penton extended a very cordial invitation to Western foundrymen to attend the Pittsburg convention of the American Association.

A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

AMERICAN MACHINEST.

May 4. An illustrated article by L. C. Jewett, on "Cupola Capacity, Tuyere Area and Arrangement, Blast Pressure, Charging Cupolas, and Design for a Cupola." Mr. Jewett says, in part: Cupolas under 26 in. diameter should be hung on trunnions. Anything smaller than this is too small for regular use, because of the difficulty of working in it in trimming out. The combined area of tuyeres should be at least 25 per cent greater than area of cupola, and the same is true of the blow pipe. Tuyeres should be tapered, so as to facilitate removal of chilled iron and slag that will get into them at times. One tuyere should be 1½ in. lower than the rest, placed above the tap hole, and provided with peek hole, so that early warning may be had as to when to tap. Shell should be large enough to take double lining as high as charging door, the two lower rings of shell to be ¼ in. thick. An auxiliary upper row of tuyeres expedites melting. In cupolas up to 40 in. diameter, the lower tuyers should be 18 to 20 in. above bottom doors, and upper tuyeres 16 to 20 in. above these. In cupolas of 72 in. diameter the lower tuyeres should be 26 to 30 in. above drop doors.

In beginning to work a new cupola, let the coke bed be, if anything, a little too deep, and thereafter modify according to requirements. Charge 400 to 600 lbs. iron to every 100 lbs. fuel on bed, then follow with fuel equal to about 10 per cent of amount charged on the bed, and iron, same as charged on the bed.

Depth of bed should be gauged, and not weighed.

The illustration presented with this article is a sectional view of a cupola designed by Mr. Jewett.

John E. Sweet illustrates a plan for parting at a rounded corner.

May 11. Under the caption, "Cast Iron Dies," R. I. Clegg explains and illustrates the methods of making cast iron dies and

the "licker-up" and "force" used for shaping sheet metal work. The die pattern is formed by casting plaster Paris upon the outside of the required shape, which may be a dish borrowed from the store for the purpose. The "force," or opposite die, is formed of lead, cast into the lower die, and extending above it to the height of a bank of clay placed around for the purpose. The "licker-up" has a key on the back, like any other die for fixing it to the drop, and the face is covered with projecting dovetails, which, when the drop falls, sink into the lead force and "lick" or pick it up. A few drops of the hammer are sufficient to cause the lead to form compactly around the dovetailed projections.

C. Vickers writes on "Light Brass Founding." To make light brass castings that will have a good appearance, the sand must be fine and the metal must be specially mixed. To prevent sand from adhering to patterns, the best thing is lycopodium, an impalpable powder obtained from the club moss. A good metal for fine work, that will "color" well, is 16 parts copper, 1 part zinc, 1 of tin and 1 of lead. All flasks should be well secured against straining by making a level top and using level weights, or by clamping a board on both bottom and top. The flasks or molds should be so set that all metal will run down hill; for this reason, the lighter patterns on a card should be located farthest from the pouring gate.

IRON TRADE REVIEW.

May 4. A method of casting steel ingots is illustrated and described in this number. The method consists essentially of a water-cooled chill on the face side, or bottom of mold, the metal entering through a series of branch gates at different heights at the side, whereby a hard or chilling steel may be cast upon the face of the mold, and a softer grade for the remainder of the casting may be introduced without agitating the iron that first entered, thus facilitating rapid solidification of the latter and preventing mixture of the two (or more) grades of steel in the mold. The process is made more practical by the use of stoppers at the head of the down-gates, within the pouring basin.

May 11. In an article on "Sound Castings," by Henry Han-

sen, he says, in part: Two ways are open for closing the grain and making the iron stronger. One is the addition of low grade pig iron. The other is to remelt the open-grained iron, which brings the molecules in closer contact. * * * The latter will produce greater softness with an equal amount of strength. * * * For this reason scrap is valuable. The addition of scrap will give the greater strength with equal softness. * * * There is really no such thing as inferior iron or bad iron to the man who knows how to use it. Iron melted hot will make clean castings. "Every cupola having its melting zone, above and below which no melting occurs, it seems to me that it would be possible that in a heavy charge the pig iron would occupy the entire zone, thus preventing any scrap from melting until part of the pig iron has been removed by the same process." This might make castings of ununiform quality. "Holes in ordinary grey iron castings are always caused by conditions existing outside of the pig iron in the cupola."

With iron melted at the proper temperature, the cause of dirt and holes in the castings lies entirely outside of the cupola, pig iron and scrap. To sum up: All iron is good iron if a man knows how to use it.

THE FOUNDRY.

Oscar Oldman writes on "How to Use Plaster Paris." To get just the right proportions of plaster and water requires considerable experience, but there is a good range of latitude permissible, and anyone can use it successfully after a few trials. Patterns for chills, or other things that must fit irregular surfaces, are made by casting the plaster directly upon those surfaces. Fine, wet sawdust is used for "banking up" around spaces that are to have plaster cast upon them, and all surfaces are oiled where plaster is to touch. A method for mending broken plaster casts is illustrated. Grooves are gouged in the surface, across the fracture, nails laid in, and then thinly mixed plaster is poured in and struck off level, and when solid the mend will be good and strong. Fragile plaster patterns should have forms of plaster

cast upon them, so that, if they become broken, their proper shape may be restored by placing upon the form in mending.

R. D. Moore has an illustrated article, describing a method for securing standard size core prints, or cones, a lifting beam, etc.

Upon the subject of evaporation, Mr. Moore says, in part: The drying power of a core oven depends upon the amount of cores in the oven, or rather, the amount of evaporation. Giving an illustrative example, he says: A potash kettle weighing over a ton was lost by the dry sand mold being extremely green, although in the oven 44 hours, that length of time having been found ample for drying each of 100 other similar molds. A heavy Sunday rain had found a new leak through the wall, and saturated the whole floor of the oven, adding greatly to the amount of steam generated.

Conversely, a large core was dried in a small oven, with the result that, because of small proportionate evaporation required, the core was badly burned.

Concerning rolls cast in dry sand molds, Mr. Moore says that the mold will contract a little at the joint, and therefore should be enlarged somewhat at this point by shaving. To prevent elongation of mold, sponge the joint well just before closing.

P. R. Ramp gives a case of "pouring under difficulties," wherein he relates how he poured a casting weighing 40,000 lbs. with one 7-ton, two 5-ton and one 3-ton ladle, manipulated by three cranes.

E. C. Wheeler has an extended article on reverberatory furnaces in malleable iron practice, and also gives a plan by which a chemical laboratory for foundry purposes may be established at a cost not to exceed $150.00.

"W. R." contributes an article treating on molding sand, facing sand and core sand.

An article by James A. Murphy on the "Making of Projectiles" is elaborately illustrated.

C. Vickers answers some questions with regard to brass founding.

W. J. Keep describes a method for recovering iron from cupola cinder. The iron-carrying cinders and the ladle skulls, etc., are thrown into the cupola after the last tap, and as it melts down iron and slag both are permitted to run out into a sand bed. The slag hardens on top, and the iron forms in a slab below. By this method the tumbling of the cinders is made unnecessary.

THE TRADESMAN.

May 1. Under the caption, "The Utility of Excogitation," E. H. Putnam writes, in substance: The idea that cast iron takes a perfect impression of the mold because of the alleged fact that it expands at the moment of solidification, is ludicrous. The green sand walls of the mold are not sufficiently firm to act as a forming die for shaping cast iron at the moment of solidification. The fact is, that the fluid iron runs into and completely fills every part of the mold, and does not begin to contract till after solidification, and this is why it makes a perfect cast, reproducing the conformation of the mold walls. He further says: I do not deny that iron expands at the moment of solidification, but I assert that the impression of the mold is necessarily taken before that moment arrives, while the iron is in a perfectly fluid state, and that, as effect cannot antedate cause, therefore expansion has nothing whatever to do with perfection of the impression.

Of gating large thin castings, difficult to run, he says: In the case, for instance, of large sugar kettles, where the branch gates enter at equal distances apart, all round, if there be too many gates there will be difficulty in running the casting, and a reduction of the number of gates will entirely overcome the difficulty, because where the branch-gate capacity in a case of this kind much exceeds the supply of inflowing iron, those gates nearest the pouring gate pass all, or nearly all, of the iron, with the result that the portion of the kettle rim remote from the pouring gate must be filled by iron that has flowed a long distance in a thin space within the mold cavity, and has become dull. Diminishing the number of branch gates will cause the iron to flow with approximately uniform force through all gates, and the iron

thus enters the mold everywhere at an approximately uniform temperature, and a perfect casting results.

May 15. Mr. Putnam here describes a core box made of molding sand. The method consists simply of making a core of wood, then molding it up in green sand, ramming it very hard, then, withdrawing the pattern, the space is filled with core sand, just as with a wooden core box. The molding sand which forms the core box is removed after drying. Cores of almost any shape or size can be made in this way, and frequently the method may save time and expense.

On the subject of "Pouring Heats," Mr. Putnam says: Many molds are lost simply because the molder does not realize that the pouring basin ought to be constructed with as great care as any other part of the mold. The outlet of the pouring basin should be narrow at the juncture with the down gate, and a little shallower than at the larger part where the stream of iron falls. The walls should be vertical, so as to obviate the liability of the iron's shooting out during the process of pouring. If, added to these features, the down gate is properly proportioned, it will be easy to keep the basin full of iron, on the surface of which the dirt will float, instead of running into the mold with the iron, as it often does when the pouring basin is not properly constructed.